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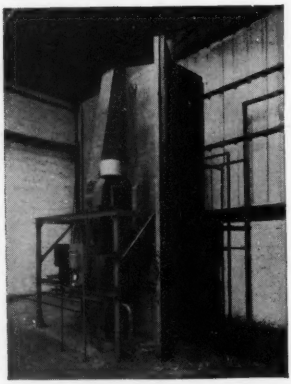

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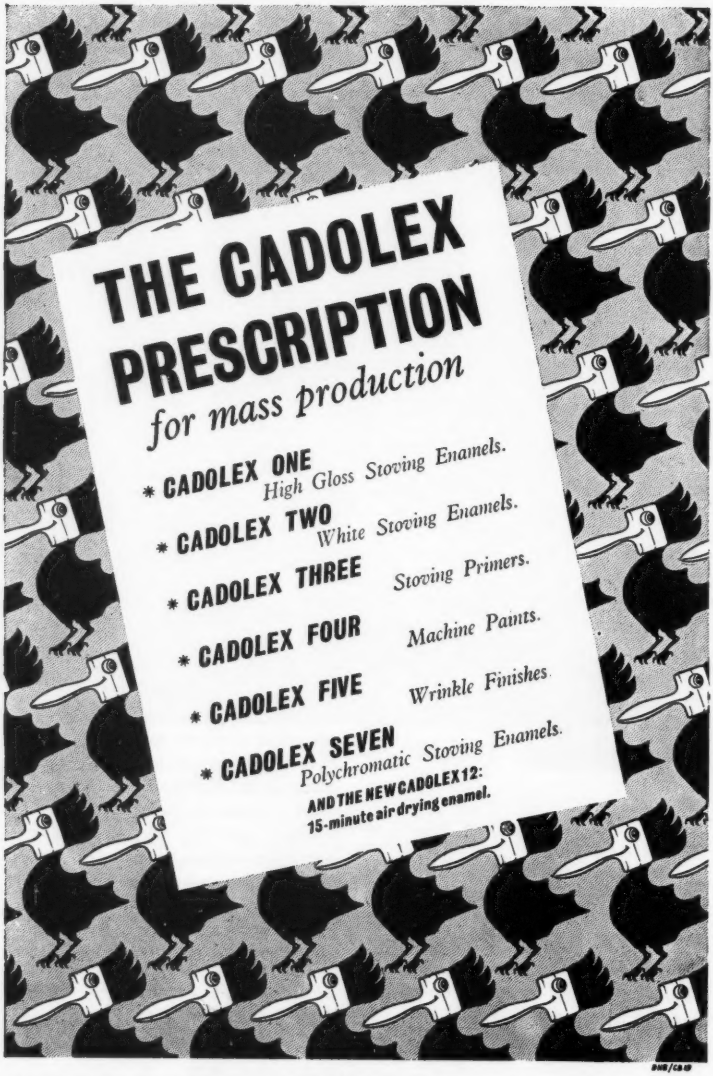
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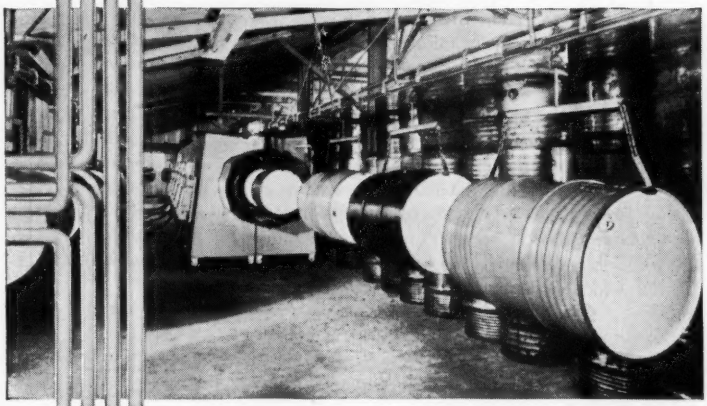

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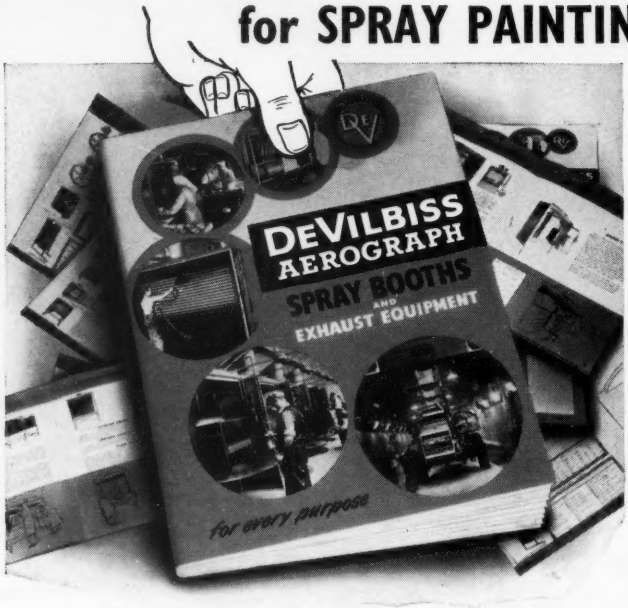

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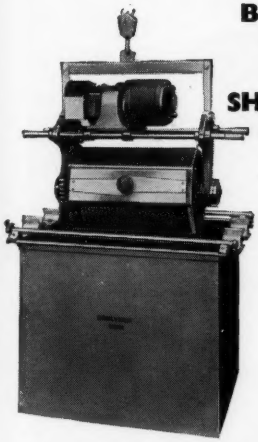

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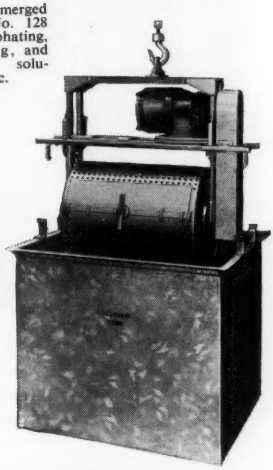

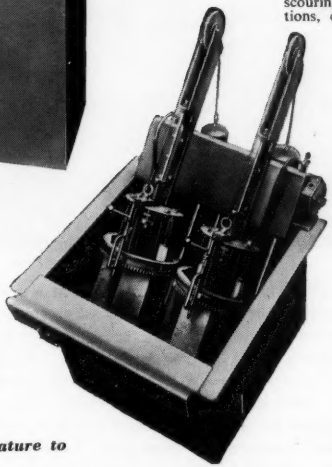

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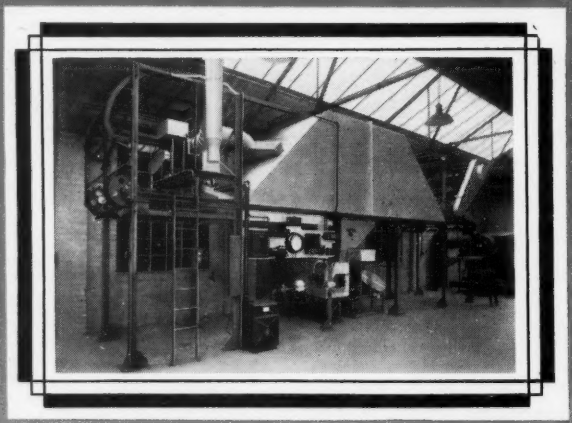

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Industrial Finishing

VOL. 6 JUNE, 1954 NO. 72

A PRESIDENTIAL MESSAGE

ON considering the recently held 4th International Conference on Metal Finishing in retrospect one is perhaps better able to assess its true value than one could before or during Conference week. That the Conference was an unprecedented success seems to have been generally agreed. Let us consider to what factors this success is to be attributed.

Forgetting just for the moment all questions of organisation, I think that the main reason for the success of this Conference was the unbounded enthusiasm of all those who attended it. If anyone had previously doubted that metal finishing was not progressing, both in research and development, this Conference must have provided convincing evidence that such doubts had no foundation in fact. Although the technical sessions were, perhaps, a little overburdened, due to considerably more papers being submitted than we had budgeted for, each session was more than well attended. The discussions were spontaneous and lively, and the information brought out during these deliberations was most valuable to us all.

But enthusiasm alone is not sufficient to guarantee success. Proper organisation is essential and the provision of a good social programme is equally important. The organisation of an international conference is no easy task and is complicated by the uncertainty that always exists regarding the number of people who will be likely to attend. The attendance at this Conference well surpassed our expectations but apart from the Banquet, where accommodation was perforce limited, the organisers managed to cope admirably with our increased numbers. In all, more than 500 people registered and as twelve countries were represented the Conference can truly be described as international in character. I would not go so far as to say that there were no directions in which some improvement might have been effected. No function of this type is without criticism, however, and in this instance any criticism that could justifiably be made can only relate to minor matters, in the light of which we shall hope to profit on future occasions.

Many people worked unstintingly to prepare the ground for this Conference. They and their committees have been duly thanked but I would like to pay tribute to them once again. Many of those who attend such functions do not perhaps realise how much hard work is involved in ensuring that things will run smoothly and that a profitable and happy time will be had by all. This Conference set a high standard, both from the technical viewpoint and from the social angle and I think we can all feel gratified at the results achieved. Certainly, the enthusiasm of the participants bodes well for future similar events. We hope that this Conference has further helped to strengthen our connections with our many friends overseas and that we may have the pleasure of seeing much more of them in the years to come.

J. W. Cuthbertson, President, Institute of Metal Finishing.

Discussions of Conference Papers

THE SCIENTIFIC BASIS OF ANODIC OXIDATION TREATMENTS OF ALUMINIUM AND ITS ALLOYS

BY P. LACOMBE
Ecole Supérieure des Mines, Paris, France

AND

INDUSTRIAL METHODS OF THE BRIGHTENING AND THE ANODIC OXIDATION OF ALUMINIUM AND ITS ALLOYS

BY J. F. G. HERENGUEL, D.Sc.
Centre de Recherches d'Antony, Antony (Seine), France

THE papers were discussed together. Mr. F. HENLEY opened the discussion. Referring to Professor Lacombe's paper he said:

"Taking the paper by Professor Lacombe to start with, there are two points only which I wish to raise.

"I take first the subject of the duplex layer; that is to say, the soft layer on the top of an anodic film on the hard layer close to the metal. It has been known for a long time that there is a difference in hardness between the outer and inner layers of the film. According to the micrographs that we have seen this morning, it looks as if the change between the soft outer layer and the hard inner layer is a gradual one. However, Professor Lacombe gives me the impression from his paper that the two layers are, as it were, almost separate and distinct.

"The second point in Professor Lacombe's paper with which I wish to deal is the question of producing hard coatings. Professor Lacombe gives me the impression that hard coatings are produced only at low temperatures and low current densities. That may be an error of translation from his manuscript. It has always been my impression that, although low temperatures are highly desirable, the current densities are usually maintained at a normal figure of, say, 15 or 20 amps per sq. ft. If necessary, one has to use rather higher voltage rectifiers to achieve this current density."

At the Conference

Right:

D. M. Lyness,
C. J. A. Kellard,
Samuel Field
(Founder-President),
C. H. Rumble and
J. R. Balmer

Left:

Two American
delegates,
E. C. Rinker and
Morris M. Messing,
with O. Wright and
J. A. Bechtold

Right:

G. D. Denyier talks
with S. W. Baier
(Last International
Conference
Secretary)
and W. H. Tait

Left:

Enjoying a drink
together—
H. G. Higginson,
R. W. W. Sanderson
(Founder-Members)
and A. E. Quenzer

Turning to the paper by Professor Herenguel, Mr. Henley disagreed with the suggestion that duralumin was not very suitable for producing anodic oxide coatings which have any protective value. He instanced a test for a sulphuric acid anodising process, part of which consisted of anodising duralumin and submitting it to a salt spray test lasting some twelve months.

He went on:

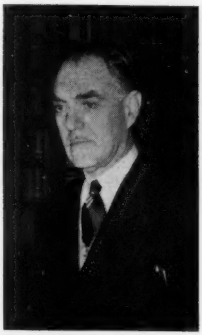
"There is also a suggestion that the aluminium-silicon series of alloys, particularly those having a silicon content of 12 per cent. or 13 per cent., do not lend themselves to the production of reasonably thick protective coatings. That is contrary to my experience and, I think, to the experience of many piston manufacturers in this country. There is an alloy, which was known for many years as Lowex, containing about 13 per cent. of silicon. It has been used for certain well-known makes of British motor cars and has been anodised for the last twenty years or thereabouts, and the oxide coatings obtained have certainly a measurable thickness and quite considerable wear resistance in their rather arduous service conditions.

"It occurred to me that there might be a special reason for the difficulty which our French colleagues have experienced. The high silicon alloys take a rather lower current density under normal anodising conditions than alloys containing magnesium or copper, and in order to obtain normal current densities it would be necessary to increase the voltage beyond the normal range. Voltages as high as 20 volts to 22 volts may be necessary. If that type of anodising is attempted with ordinary pure aluminium suspenders, the pure aluminium suspenders behave rather differently from the silicon alloy in that the breakdown voltage of pure aluminium coating is exceeded and very often the suspenders will completely dissolve away. By the use of a high silicon alloy suspender, that difficulty can be overcome and reasonable thicknesses can be produced with silicon alloys. They have been used by the Admiralty in the anodised state for marine work."

Mr. A. W. BRACE: "I should like to add to Professor Herenguel's point about hard anodising. Campbell's work has shown that by using superimposed A.C. on the normal D.C. it is possible to use current densities as high as 150 amps per sq. ft. The aluminium-magnesium-silicon alloy HE10 enables one to produce a three-thousandths film in nine minutes in a bore of 5 in. diameter and 11 in. depth, making provision for circulation of the electrolyte, and in addition American work has indicated clearly that high voltages are just as essential to the production of hard films as are low electrolyte temperatures. In fact, they are probably a little more important.

"With regard to chemical polishing, which is becoming increasingly used in this country, Professor Herenguel seemed to suggest that the phosphoric acid base electrolytes were the only ones worthy of consideration. However, some important results obtained by Helling and Keunzig in Germany show that with a super-purity aluminium alloy containing 0·5 per cent. of magnesium the total reflectivity obtained with a 15 mu film was 84·5 per cent. and the specular reflectivity 74 per cent. With the V.A.W. process the total reflectivity was 86·2 per cent. and the specular reflectivity 76·8 per cent. Similar results were obtained with aluminium containing 2 per cent. of magnesium, the figures being 82·5 per cent. total reflectivity and 66·5 specular reflectivity and, using the V.A.W. process, 85 per cent. reflectivity and 71·5 specular reflectivity. That shows that where high reflectivity matters there is some benefit in considering the HNO_3 fluoride type bath, and it points to the need for a much more careful evaluation of these processes."

Dr. H. FISCHER: "Professor Lacombe has discovered a very interesting isotropy in the monocrystal concerning the thickness of the films. We also found an isotropy in the chemical anodic polishing process. In anodising we have two stages. The first stage is the anodic dissolution and the second is the formation of the film. In the case of the anodic polishing, it is possible that the dissolution process is the reason for the isotropic attack because in polishing the stage of dissolution is much



Above: Dr. H. Sänger

Above: Dr. R. Springer talks with Dr. R. Halroyd, Research Director, I.C.I.

Right: Prof. H. Hohn (Vienna) with Prof. H. Fischer (Karlsruhe)

THE I.C.I. . . .

Photographs on this page show some of over 400 delegates who attended the informal party given at the dining rooms, I.C. House by I.C.I. Ltd.

Guests were received by Dr. R. Halroyd, Research Director, I.C.I., pictured here.

. . . RECEPTION

Left: Mrs. Sutherland, Mrs. Cowlard, Mr. L. A. Williams (Metrovick) and Mr. T. Cowlard (T.C. Spray Finishing System)

greater than the stage of film formation. We also find a little film in every anodic polishing process. Have you a preferred figure for the dissolution stage, and is it an isotropic effect or an oxidation process?"

In the opinion of Professor LACOMBE the very great difference in the development of anodic oxidation between France and Great Britain was in the preparation of the applied surface for the decoration. He continued, "In France, this point of view has determined the elaboration of special alloys or special aluminium of high purity to obtain the best condition for anodic oxidation.

"In my opinion, it is not possible to obtain very good anodic layers with aluminium-copper-magnesium and aluminium-silicon-magnesium alloys."

"On the decorative side, as I think is known by my colleague, Professor Herenguel, with regard to the anodic layers, the anisotropy is due to the dissolution of oxide at the beginning of the anodic process, but I do not think that that is an explanation of the anisotropy. Anisotropy is observed in a few baths of anodic oxidation. It is possible to obtain anisotropy with sulphuric acid in oxalic acid or phosphoric acid only. In these different baths you have a very different spread of dissolution. We always expect to achieve anisotropy according to our orientation of crystals."

PHOSPHORIC ACID ANODISING OF ALUMINIUM AND ITS APPLICATION TO ELECTROPLATING

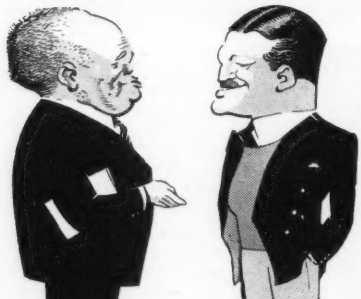
BY R. C. SPOONER AND D. P. SERAPHIM

Aluminium Laboratories Ltd., Kingston, Ont., Canada.

THE discussion was opened by Mr. A. W. WALLBANK who began by a criticism of the crudeness of the bend test of adhesion, and thought it a pity that the paper had not been supported by something a little more definite.

Mr. Wallbank was most interested in the possibilities of the process as a commercial proposition. One drawback, he saw, was the fact that if there has to be an anodising stage in a preplating sequence, the whole of the cathode has to be aluminium, and preferably of the same alloy. Obviously, too, any sort of mixed metal assembly is out of the question. Even for wholly aluminium articles the snag of jigging crops up. He concluded:

"The economics worry me. I have never seen the process in operation, but presumably you have to have aluminium jigs with good positive contacts. Do you anodise and plate on the same jig, or do you unjig after anodising and rejig, on copper wire for plating, or if you use the same jig all the way through, what do you do to it then? Presumably it has an anodic film with a metal deposit on top. Do you have to strip it down to the basis aluminium every time? It is these matters which puzzle me, and I should welcome more information. What is the effect of the process or similar anodising processes on the polish of the basis metal? Having polished a bit of aluminium hollowware, it is a shame if you reduce it by anodising pretreatment."



Mr. F. A. OLLARD mentioned that some laboratory samples had been tested in a salt spray with some done by the zincate system and they stood up to the test much better. Because of the difficulties raised by Mr. Wallbank they had not pursued the matter.

Mr. A. W. BRACE mentioned the apparent discrepancy between the

findings of Spooner and Seraphim and those of Keller, Hunter and Robinson of the Aluminium Co. of America.

"Work by Keller in which he anodised aluminium in a variety of electrolytes, stripped the film from the basis metal using a phosphoric-chromic stripper and followed over that with 3 per cent. tartaric acid electrolyte, showed a structureless blocking type of film which reproduces the cell base pattern. Mr. Brace illustrated his point by a slide.

"The slide shows pores in films at various forming voltages. A phosphoric acid anodised film gives a much greater percentage of pores than do any other films. This would appear to be one of the reasons why this process is successful. But Spooner's work was carried out at around 40-50 volts, giving a porosity of about 5 per cent., which is slightly less than that obtained with normal sulphuric acid anodising, which is carried out at about 12-15 volts.

"I suggest that the reason for the discrepancy is that Keller's work has been carried out by measuring the porosity at the base of the cell—that is, at the interface between the oxide film and the metal—while Spooner is basing his observations on the behaviour at the top of the anodised film. We probably have conditions where the pore has certain sections to it, and while the size of the pore and the overall volume is similar at the top, due to the solvent effect of the electrolyte you have a far bigger volume.

"The heating effect produced in the anodised film is proportional to V^2/R, and so, as you put the voltage up, you appreciably increase the heat produced in the anodised film, which will again encourage a much greater solution at the top of the film than at the bottom.

"Mr. Bruce indicates that you can use a much lower voltage—about 25-30—although some attention should be paid to the fact that the thickness of the barrier layer, according to Keller, is about 1:1 to 1:2 times greater than that of the cell wall thickness, but the differences between the different electrolytes rather straighten themselves out and you get very similar barrier thicknesses for corresponding voltages.

"With regard to the difficulties when dyeing, it would be interesting to know what sort of dye it was. If it was pure absorption, it would probably be washed out if what I have said was correct. If it was one forming a lake, it is difficult to understand why it did not dye. Why not try a low voltage sulphuric acid film instead of phosphoric, which is equally simple and far more common? It is possible to get films as low as 7 or 8 volts. You

have to bear in mind that you appreciably reduce the throwing power of the metal by it, and that can be a limitation."

Dr. W. BLUM spoke of exploratory observation made during the last few months by the Bureau of Standards on magnesium oxide coatings on magnesium.

Some measurements were made recently on these oxide coatings on magnesium, on the total surface as measured by the mono-molecular nitrogen method. They indicated that on the coatings of magnesium the total area was from 50-100 times the projected area of the specimens. That indicates a relatively high porosity. If some of those who are working with aluminium would try that procedure it would give an independent indication of the degree of porosity in different coatings.

Mr. B. E. BUNCE talked about his experience of the process for plating. The process had been used for about eighteen months when it was difficult to get brass.

His firm did not use pure aluminium alloys. Research found they did not produce very good coatings. They found it difficult to get bright plating on a pure aluminium alloy, but got excellent results by using a 2 per cent. to 3 per cent. copper alloy. It was possible to anodise this alloy at about 16 volts at about 12-15 amps per sq. ft. They found it possible to

directly bright nickel plate it using a cupro-nickel plating process or one of the more recent organics.

Dealing with some of the points raised by Mr. Wallbank, he said:

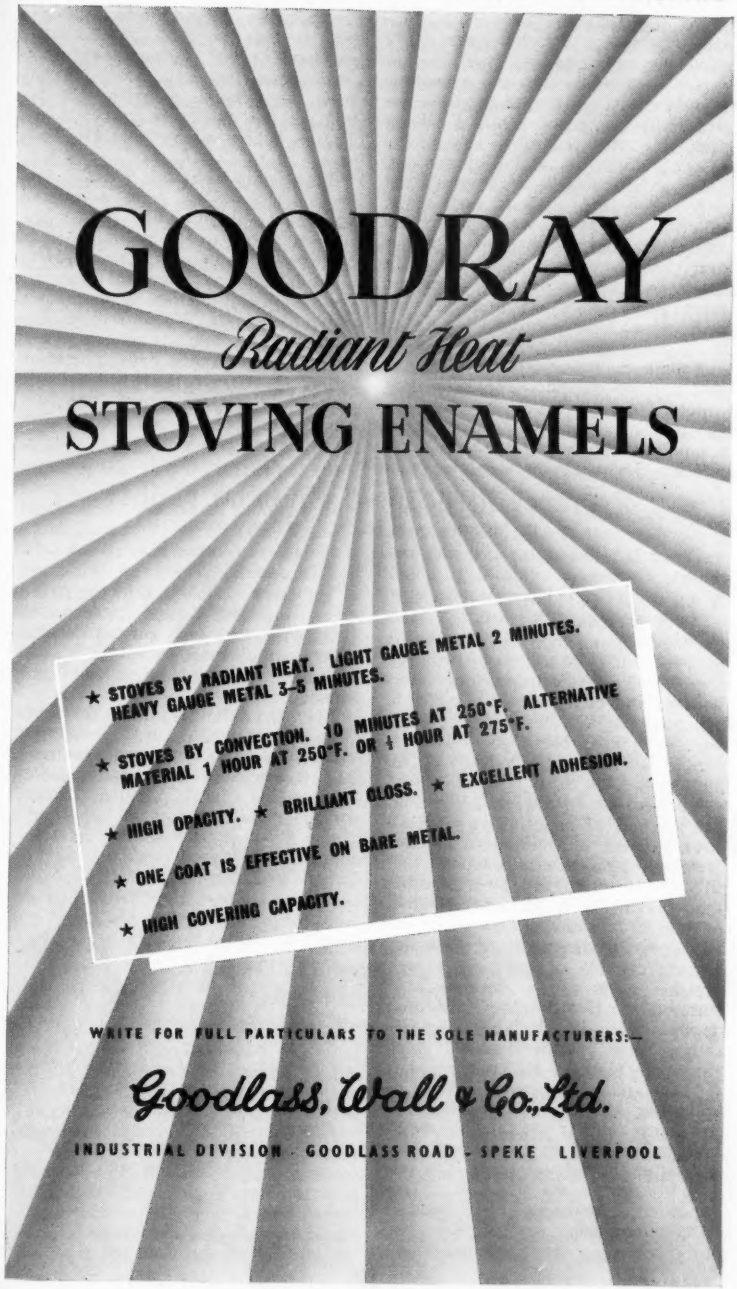
"We found that if you did not have too high a concentration of alloying medium you got fairly good adhesion. With the 2 per cent. to 3 per cent. copper alloy we found that the adhesion was of the order of the basis metal.

"From the point of view of economics, it was definitely more costly than directly plating brass.

"From the finishing point of view, we also found that we got excellent results by just chemically polishing the parts and directly nickel-plating them from that point. The loss in polishing is relatively small if you use around 2 per cent. to 3 per cent. of copper. If you increase the alloying constituent you definitely lose finish.

"From the corrosion point of view, the alloy that we used—the 2 per cent. to 3 per cent. of copper—was quite good directly nickel-plated. As to corrosion from an industrial point of view, we left samples out in an industrial atmosphere for up to twelve months with quite good results, but corrosion in a humid atmosphere was not very good.

"We found it possible to plate aluminium diecastings. A typical example that we have recently done for the Aluminium Development Corporation was a 4 per cent. silicon-6 per cent. copper alloy, on which we found it was possible to produce a good nickel coating if you put on about a thousandth and anodised at about 6 volts. We also found it possible to plate the 13 per cent. silicon, the L33 alloy, at about 13 volts."


GOODRAY
Radiant Heat
STOVING ENAMELS
★ STOVES BY RADIANT HEAT. LIGHT GAUGE METAL 2 MINUTES. HEAVY GAUGE METAL 3–5 MINUTES.
★ STOVES BY CONVECTION. 10 MINUTES AT 250°F. ALTERNATIVE MATERIAL 1 HOUR AT 250°F. OR ½ HOUR AT 275°F.
★ HIGH OPACITY. ★ BRILLIANT GLOSS. ★ EXCELLENT ADHESION.
★ ONE COAT IS EFFECTIVE ON BARE METAL.
★ HIGH COVERING CAPACITY.
WRITE FOR FULL PARTICULARS TO THE SOLE MANUFACTURERS:—
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Mr. J. COYLE, spoke of a significant difference between the work reported here and the work earlier reported in relation to the pyrophosphate bath, the fact that the bath has a low *p*H value of about 8. Being virtually neutral, it has less of an attack on the film of the aluminium.

Dr. GARDAM, who presented the paper for the authors, in reply, pointed out that this was a laboratory study. He continued: "Mr Spooner and Seraphim were definitely not enamoured of the process. They are much more interested in the zincate process and have published what may be a significant improvement in it, and that electrolytic removal of the zinc and reformation. Therefore, you should not press the authors too far as to what they think of this as a commercial process.

There is no doubt whatever that the porosity as measured by Keller was a base porosity, and what is involved in the plating is a sort of final shape, general overall porosity. It is the amount of earth that you hold in the cracks in crazy paving. That is confirmed by what Dr. Blum says.

To take up what Dr. Wernick said, we shall have to plate aluminium whether we like it or not.

With regard to the point raised by Mr. Coyle, the united chromium-pyrophosphate was successful for the reason that he mentioned, that it was virtually neutral. With an aluminium oxide coating, you cannot use a very acid or very alkaline bath. Therefore, unless the first bath is substantially neutral, you will attack the aluminium before you get a coating on and thus get no adhesion.

ELECTROLYTIC POLISHING AND METAL FATIGUE

BY R. MONDON AND H. E. ZENTLER-GORDON

1951. Société Jacquet-Hispano-Suiza, Paris, France, Modern Electrolytic Processes and Patents Ltd., London

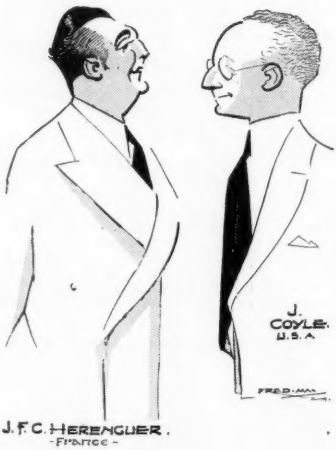
MR. R. A. F. HAMMOND opened the discussion. He was interested in the vapour honing process as applied to the restoration of compressive stress in electropolished components and details of what could be achieved in this way. He queried whether honing could go down to a depth of three-thousandths as the author said.

He went on to suggest an alternative method of restoring compressive stress by the application of a compressively stressed electrodeposit such as zinc. He continued by mentioning the work of Mr. Logan of the Bureau of Standards, showing how chromium may possibly be used as a surface coating capable of applying a compressive stress to an electropolished component. Heat-treating chromium deposits very largely eliminated the fatigue loss which resulted from chromium plating. He concluded:

"In some recent work which my colleague, Mr. Williams, has done, he has found—this is not yet published—that by suitable heat-treatment of a chromium plated test piece it is possible to reverse the stress in electrodeposited chromium and get, in effect, a compressively stressed layer of chromium on a steel component."

Mr. J. F. KAYSER thought that there was little future for processes calling for such high current densities as electropolishing, except as a sensitive method of inspection for highly stressed parts.

Mr. O. WRIGHT continued the discussion. He said, " As a result of an article published by the Napier Laboratory, we held quite a lot of



discussions with the authors. We agree with a great deal of what they say, but we do not go the whole way with them. We believe that one of the causes of failure, apart from the fact that you get a definite drop in fatigue value, is due to micro-pitting. This is one point where we are in disagreement with the authors.

"The author mentioned a three-thousandths disturbed layer. We have had evidence which could not be seen under the microscope at 2,000 diameters of a disturbed layer or faulty machining having an influence when fifteen-thousandths of metal had been removed by electropolishing.

"We got down to a technique of preparing our basic standards, and as a result of that the slides will show that we did not get any scatter on electropolished specimens. It is because of that that no marks are made on the slide. There was no scatter. In fact, we ran test pieces against a stop-watch instead of against the clock on the test machine, and, by carefully watching, we got specimens of test pieces with the initial cracks prior to the rupture of the specimen.

"The author has suggested that one of the reasons for the scatter in Figs. 3 and 4 as against that in Figs. 1 and 2 is the amount of metal being removed. We agree with him, but if we have a perfectly mechanically-prepared test piece prior to electro-polishing, we find that it does not matter whether you take half a thousandth or thirty thousandths because you still get the same ultimate result.

"We did some work which suggests that although the amount of compression or disturbed layer that you have has some effects or irregularities, the actual ideal layer is in the nature of three or four millionths of an inch. It is too fine to be measured by any known method of measuring. We have gone on further with the work, and some of it is not ready for publishing, but at ten secs. anodic etch on DDD·901 in strong sulphuric acid dropped the fatigue value from 39 to 34, which is very nearly the same as the drop in electropolishing with five, ten or fifteen-thousandths."

Mr. H. E. ZENTLER-GORDON in reply to Mr. Hammond said, "I think that vapour honing is an attractive technique. The main disadvantage is that it is wet. The vapour honing process will, we hope, be superseded by a similar technique, possibly in a gas phase, which is much more convenient and possibly less expensive.

"The idea of reintroducing compressive stresses by an electrodeposit such as zinc is very attractive, but we should not forget that this is a cathodic process with all the disadvantages of cathodic processes, possibly with hydrogen embrittlement. We have yet to be convinced that the deposition process can be controlled in such a way as to reintroduce stresses in the right direction. If, instead of compressive stresses we introduced tensile stresses, there would be no advantage.

"In reply to Mr. Williams and his valid-criticisms of my Figs. 1, 2, 3 and 4, I would point out that there was practically no scatter in the case of Fig. 2. The results obtained in each case were the average of at least six readings, and the work was very thorough and well supervised.

ON THE EXPERIMENTAL METHODS FOR THE DETERMINATION OF ELECTRODE POLARISATION

BY R. PIONTELLI, PH.D.

Laboratorio di Elettrochimica, Chimica-Fisica e Metallurgia del Politecnico di Milano, Milano, Italy

THE discussion was opened by Dr. J. EDWARDS. Referring to the Luggin capillary for the measurement of electrode potentials, he said:

"We have on the whole been very pleased with it, but there are some difficulties, especially if one wants to measure potentials over a long period of time when there are changes in the shape of the electrode due to deposition or dissolution as well as changes which naturally occur in the composition of the solution. It is also important to ensure a good fit on the electrode surface.

"Disastrous consequences can ensue if there is a change or a likely change in the electrode process if, for instance, a portion of the electrode is half shielded at the point where you

are making the measurements.

" In certain circumstances the capillary is useful. It minimizes screening and resistance effects and it is convenient to use."

Dr. F. SALT: "My idea of a possible easy way of overcoming the trouble due to drop in measuring potentials is to have the cathode at the end of a horizontal tube, the anode being at the other, and there being a small gap between the cathode and the tube with a diaphragm in between to prevent mixing effects. This gives a uniform distribution of current density over the cathode. You do not completely cut out drop, but, provided that the gap is small, very little current goes round the back."

RADIOTRACER STUDY OF ELECTROCHEMICAL DISPLACEMENT ON METALS

BY M. SIMNAD, PH.D., A. SPILNERS, B.S., AND LING YANG, PH.D.
Metals Research Laboratory, Carnegie Institute of Technology, Pittsburgh, Pa., U.S.A.

T. P. HOAR drew attention to the fact that the displacement rates did not differ greatly between iron, copper and nickel, which pointed to diffusion control or another rate-determining process. A. E. DAVIES suggested that fruitful application for radiotracer techniques in electrodeposition were the study of immersion deposits on anodes and the investigation of cathode reactions, such as Ogburn and Brenner's recent work which demonstrated that Cr^{+++} took no part in chromium deposition. A number of problems were left unanswered in this paper, e.g., how thick were the heat-treated oxide layers, and was there evidence of redeposition of the anodic metal with the silver, and if so, how did the ionic activity affect redeposition?

W. L. MEYER discussed the insufficiency of the electrochemical series in predicting the reactions taking place in solution. In cyanide solutions, it was possible to deposit lead on copper, due to complex formation. G. D. DENYER described the use of radioactive zinc, Zn_{65} to determine the effect of zinc chloride in flux under hot dipped tin coatings on steel. At Harwell, radio tracers were used to determine the thickness of Cu and Ni coatings on steel. The method might usefully be employed for determining the best conditions for, e.g., tin immersion coatings on aluminium as an alternative to zinc in plating pretreatments. In immersion deposits from Au-Ag solution according to N. E. TIDSWELL one or other metal was deposited alone, depending on which was in excess. The dynamic equilibrium $Ag \rightleftarrows Ag^+$ in the $Ag/AgNO_3$ system was shown well by the use of radio active silver, according to D. N. Layton. On copper single crystals, Cu-Au and Cu-Ag solid solutions were formed in Au and Ag solutions.

MORPHOLOGY OF THE GROWTH OF ISOLATED CRYSTALS IN CATHODIC METAL DEPOSITS

BY HELLMUTH FISCHER, DR. HABIL AND HEINZ FELIX HEILING, DR. ING.
Technische Hochschule, Institut für Physikalische Chemie und Elektrochemie, Karlsruhe, West Germany, Technische Universität, Institut für Metallhüttenkunde, Berlin-Charlottenburg

THE independent but on the whole similar classification of types of deposit suggested by G. I. FINCH and collaborators was referred to by D. N. LAYTON. Here deposits were described displaying *lateral* growth (corresponding to the BR type) and *outward* growth (corresponding to Fischer' field-oriented type) though these did not necessarily form isolated crystals, but could form compact layers). In deposits apparently of the BR type, they had often found by X-ray diffraction that in reality the deposit reproduced not the crystals but only the grain boundaries. At the same time, the outward growth of FI type crystals did not always seem dependent on the current lines as was demonstrated by changing the anode position during electrolysis. For this type, too, a fairly high metal ion concentration was necessary. According to N. Stuart, the growth form could be varied merely by changing concentration as shown in lead crystals growing through gels of different concentrations of lead acetate. H. Fischer stated

that his work was concerned with thicker deposits (10^{-3} to 10^{-1} cm.) than G. I. Finch's (10^{-8} to 10^{-5} cm.), in which there was a greater effect of the substrate. The effect of metal concentration was complex and dependent on the degree of dissociation.

CORROSION OR PROTECTION AT GAPS IN METALLIC COATINGS ON STEEL

BY U. R. EVANS, SC.D., F.R.S.
Department of Metallurgy, University of Cambridge

S. C. BRITTON distinguished between pores growing normal to the surface and the worse attack due to lateral corrosion under the coating. In the case of tinned steel the polarity of the system may depend on the exposure. The outside of such tins when exposed to rain often showed corrosion of the iron spreading sideways. In extreme cases filiform corrosion may follow this type of attack. The physical obstruction offered to moisture in very thin pores, e.g., in sprayed coatings, and the ability of atmospheric rust to seal pores was often under-estimated, particularly in long pores. At the sea-coast, however, rust was less protective. Cathodic coatings should be wiped frequently to remove moisture holding corrosion products. The protection of sprayed Al was due largely to the barrier against moisture set up by corrosion products formed by lateral attack at the base of the coating. W. A. Westley differentiated between three types of pores formed in cathodic plated coatings. Narrow pores and those wide pores which were produced in plating and could be rejected in inspection were of small account compared with wide pores formed in service. According to Lancey small pores may grow larger due to the high corrosion c.d. F. W. Salt referred to the fact that tins holding fruit juices were often lacquered. In other cases, initial rapid corrosion of iron followed penetration, accelerated by the oxide film. According to U. R. Evans unlacquered tins sometimes lasted better than lacquered. The initial high rate of dissolution is due to cathodic reduction of the rust, after which the attack stopped.

CLEANING AND PREPARATION OF METALS FOR PLATING

BY W. R. MEYER
President and Research Director of Enthone, Inc.

ALL methods of cleaning and preparational procedure for electroplating should produce clean, active, coherent strong surfaces. Unfortunately, few cycles of cleaning do this. Improper surface preparation can have results more harmful than just peeling or blistering of the electrodeposit. It can also cause "spotting out," poorer plate distribution or coverage, poorer corrosion resistance, cracking of the coating, duller or rougher plate, nodule formation, and induce higher diffusion rates.

Every cleaning procedure should be concerned with these problems: (1) Does it remove all matter from the surface of the metal both organic and inorganic? (2) Does it remove all oxides? (3) Does it deposit any films to lessen adhesion? (4) Does it attack the basis metal, and if so, is there preferential attack on some of the constituents? (5) Does it cause hydrogen embrittlement? (6) Does it weaken the metal to lessen tensile or fatigue resistance? (7) Does it remove weak or loose conductive metal at the interface to form a metallurgically sound surface?

The ideal procedure should obviously meet all these requirements, but in many cases it is not possible to do so. When considering a cycle for preparing work for electroplating, please keep these factors in mind. Too many poor procedures are in use today causing poor quality of plating. We would not consider building a house on quicksand, but we are doing this when we electrodeposit a metal upon loose carbon, metallic particles, severely worked surfaces.

Let me now deal with some of the cleaning practices. How can buffing and polishing compounds be removed? Unfortunately, there is no one ideal procedure. One must be careful, however, to pick a procedure that removes both organic and solid inorganic dirt so that a dust is not left on the surface.

Methods used include: (1) immersion or spray in chlorinated solvents with vapour condensation (these procedures often leave dust), (2) soap soak cleaning with agitation of the work (cutlery industry), (3) spray cleaning with mixtures of solvents and water, (4) solvent washing, (5) alkali cleaning, and (6) emulsifiable soaking or spray followed by a water rinse. The jewellery industry frequently achieved excellent results from method (6) followed by a steam spray rather than a water spray.

There has been much controversy over whether anodic, cathodic or both cathodic and anodic cleaning should be used. Cathodic cleaning is used because the larger volume of gas formed at the cathode would appear to cause faster cleaning than at the anode and also there is less staining or metal attack. In regard to faster cleaning cathodically, this is not appreciably true with alkaline cleaners containing modern surfactants such as the alkyl aryl sulphonates and, therefore, other factors should be considered when deciding what polarity to use. My experience leads me to conclude that only anodic cleaning should be used providing staining or metal attack is not a problem. Anodic cleaning of steel, copper and zinc can be done without resort to any cathodic cleaning. For cleaning of brass, anodic cleaning should be done following precleaning or cathodic cleaning, but if buffed work is cleaned anodically directly a stain pattern may develop.

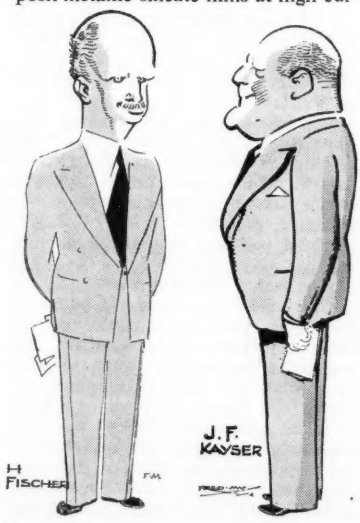
What are the dangers of cathodic cleaning? More poor plating has been caused by cathodic cleaning than by any other cause. I have known firms to almost bankrupt themselves due to faulty work resulting from improper (cathodic) cleaning, particularly of brass.

Poor work from cathodic alkaline cleaning results from the electrodeposition of metals that dissolve in the cleaner. Iron, copper, zinc, tin and other metals can dissolve in the cleaning solution and plate out. Have you not seen a piece of steel, copper or brass turn grey or black when it stays too long in cathodic alkaline cleaner? The grey is not due to tarnish—it is a plated metal smut. Reversal of the current for ten seconds will not deplate all the smut and you may be plating upon "quicksand." Reversal in the same tank is very bad and should be abandoned.

Another reason why cathodic cleaning is bad is that it does not assist in the removal of worked, distorted or flowed metal on the surface. This is particularly true for cleaning of brass, as the late Arthur Hothersall has shown. Brass should always have a final separate anodic cleaning. This deplates some of the metallic smut, but even more important, it oxidises the surface so that the cyanide or acid dips that follow will dissolve away most of the worked metal to produce clean, strong metal to serve as a good base for the electrodeposit. A thin uniform tarnish in the anodic cleaner is a good thing.

Lastly, there is a danger of hydrogen embrittlement in certain steels from cathodic cleaning. Reversal of current does not remove the hydrogen.

What are the advantages and disadvantages of anodic cleaning? The advantages include no smut deposition, oxidation of the surface to assist in removal of worked metal and solid dirt, no hydrogen embrittlement and with detergency about the same as with cathodic cleaning. The disadvantages include attack or differential tarnish on some metals such as brass, lead and zinc. Improperly formulated cleaners containing silicates may deposit metallic silicate films at high cur-



rent densities and non-silicated cleaners may cause attack on some iron alloys such as cast iron when cleaned anodically at high current densities.

ELECTROPOLISHING AND BRIGHT PICKLING

BY C. L. FAUST
Battelle Memorial Institute, Columbus, Ohio, U.S.A.

MY remarks will refer briefly to current practices of electropolishing in the U.S.A. I use the word "electropolish" throughout my remarks, because it is easier than referring all the time to chemical polishing and bright dipping; but all three of those processes have the same requirements as I shall mention in my remarks.

The commercial progress of electropolishing has depended on three factors—the development of practical methods that production people could control; the interest on the part of the mills to produce metals suitable for electropolishing; sufficient publicity to fabricators and metal finishers to use new and different metal-finishing technique.

Progress on the first point was considerably faster than on the latter two. In particular, the characteristics of the metals which were available prior to 1950 were too often unsuitable for these non-mechanical finishing methods. Then, after 1950, metals were produced with better properties for electropolishing and chemical polishing. Production people and finishing people gradually came to accept these finishes for their own quality of brilliant colour and for economic reasons. No longer are these processes expected to produce the appearance of wheel buffing or colouring. Parts for which matching appearance may be required alongside of others mechanically buffed and coloured are frequently both electropolished and mechanically colour buffed.

The most important area of publicity at first related to acquainting design and production people with these new processes. This required a simultaneous effort among fabricators, finishers and mills. Now steel and non-ferrous mills recognise and agree that these new techniques require certain properties and recognise that the properties are within the scope of practical operations. This hurdle has been a most important one since the very beginning of the two processes, electro and chemical polishing, and the advancements made because of our needs for assisting bright dipping. Now all of these are accepted commercial procedures.

The best results are obtained with fine grain metal having a single phase structure. For sheet and strip there is still need for data on the relation between the final process operations, such as cold passes for finishing, and the pitting that occurs in the case of non-mechanical finishing treatments. Grain sizes are now finer for some metals than heretofore thought permissible for deep-drawing operations. The grain sizes thought to be required for deep-drawing then are too coarse for the best results by electropolishing or chemical polishing. Now the grain sizes are as small as ·005 mil. for brass and for stainless steel as fine as ·05 mil. These dimensions refer to the average diameter of the grain. A number of mills are now producing such specimens without adding a price premium or, if they know that the metal is to be used in parts that will be electropolished or chemical polished, they will select from their stocks a material which is suitable. The mills have now restored the practice of rolling under conditions that will make the strip and sheet more readily finished. This has also assisted mechanical finishing methods. Some mills have set up electropolishing tanks in order to check their own material and see whether the customer can use it. The electropolishing activity has been increased somewhat by reason of the unavailability of nickel for protecting steel. This has led metal finishers to substitute 17 per cent. chromium stainless steel.

An interesting auxiliary use of electropolishing is to remove burrs and sharp corners that result from planing operations or from machining. We call this electro-deburring. The principle use is for parts where burrs are inaccessible for the relatively simple operations of barrel tumbling. If the part can be treated by barrel

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tumbling, this is much more economical; but electropolishing is used mainly where burrs are inaccessible for such operations. Other directions in which electro and chemical polishing are being used is for the removal of the damaged or weak layer of surface metal that results from abrasion or cutting and tearing in machining operations.

The result of such electropolishing or chemical polishing treatment is to provide about the cleanest surface that can be produced. To the usual terms "chemical cleanliness" and "physical cleanliness" I would add the term "mechanical cleanliness"—referring to the absence of mechanically damaged surface metal that traps the small quantities of oil or grease which are difficult to remove by cleaning procedures. With the absence of such trapping metal, the cleaning becomes easier.

The overall magnitude of electropolishing and chemical polishing operations is difficult to assess, because the user can choose from a number of practical methods. I do not know all of the individual ones that are in use. There are some finishers who have not disclosed information on the type of solution or the amount of work that they turn out; these appear to be production secrets. Some idea of the amount of electropolishing can be obtained, however, from the fact that one manufacturer of phosphoric acid estimated that 1,000,000 lb. per year of his product went into electropolishing use. If this were converted to a daily figure for phosphoric-sulphuric acid type of solution, it would account for from 25 to 50,000 sq. ft. of work per day. These figures are only indicative of the magnitude, and are probably on the low side. This is because the phosphoric acid is also produced by other large producers from whom I did not have figures. The acid is also used in solutions other than sulphuric-phosphoric mixture—in fact, in about five other different types.

At the present time there are at least 100 installations of 2,000 gallons or more in capacity. There are hundreds of smaller size, ranging down to 25 gallons of electropolishing or chemical polishing solution. One plant, a 4,000 gallons semi-automatic electropolishing installation, is producing 1,500,000 stainless steel parts a month.

DISCUSSION. Starting the discussion, MR. N. A. TOPE said that, because America had relatively few hand-operated plants, they had an opportunity to intersperse a large number of cleaning cycles and dipping operations each of which had to do a specific job. Labour cost made one hesitate in England to employ such detailed cycles.

In reply to questions raised in the discussion Dr. W. R. MEYER said:

"In regard to shortening the cycles, there is one procedure that is tending to shorten cycles. I know of one aircraft manufacturer who has eliminated his alkali cleaner, rinse and pickling procedure in favour of one single electrolytic treatment for the removal of oil and rust at one time.

"With regard to Mr. Smith's question about the polishing of brass, if it is cleaned anodically in a cleaner that contains sodium hydrosulphide, there can be difficulty if the chemical is too high. We usually try to keep it not higher than ½ gramme per litre. I am strongly in favour of the final anodic cleaner for brass.

"Mr. Blöchlinger asked about the removal of carbon deposits from soft iron. That is a difficult thing to do. The cathodic alkaline cleaner procedures do a reasonably good job. The procedure requires about five minutes. But probably the most effective way that I know of is to use a cold solution of 3 to 4 lb. per gallon of caustic soda. I use about 25 amperes per sq. ft.

"Mr. Marchand asked about the cleaning of soft brass. It is first necessary to preclean. This is one case where cathodic cleaning is necessary, and one must use a properly formulated cleaner."

Dr. C. L. FAUST said in reply:

"Mr. Dixon asked what we do with spent electropolishing solutions. A large proportion of the electropolishing solutions have a sufficiently long operating life that the waste material from them appears as a removable insoluble sludge, or the solutions last long enough for the normal drag out of removing the work to take care of the spent solutions. Mr. Dixon referred particularly to solutions containing phosphoric acid. These have the most finite life of all and must be dumped at frequent intervals. So far we have been fortunate in that the amount of

waste from such solutions has been small relative to the amount of normal metal-finishing waste, so that it could be disposed of with the metal-finishing waste. There are waste disposal plants installed now in many plants, and there will be additional ones in the future.

"Mr. Oswald asked about the bond strength of chromium on steels. Because of the removal by electropolishing of the damaged layer, the chomium is more firmly attached. The chromium itself is a strong metal; it does not have much elongation, but it has a rather high tensile strength, so that if there is only a weak steel surface the attachment will be weak. We have measured the strength of a steel surface where the steel would have 100,000 lb. tensile strength in the normal type of tensile specimen. The surface skin left by machining can have only 35,000 lb. of strength. This surface skin is just a fraction of a thou. in thickness, but it is the part that must support the chromium. If it is left on the surface, then the plate is not attached as firmly as it might be, but in many cases that attachment is strong enough. When there are severe stresses introduced in the chromium plated part, we must think of the surface layer and what to do about it.

"Dr. Champion asked about chemical polishing solutions for aluminium. The solution most frequently used consists of phosphoric and nitric acid. There are extensive uses of a phosphoric, nitric and acidic mixture. With the acidic acid present, the surface can be made more brilliant, but operating conditions are more difficult; the temperatures are higher and there is a penalty in the extra ventilation required for the added improvement in colour. For many purposes the nitric-phosphoric solution alone produces a very satisfactory finish prior to anodising or anodising and colour dyeing.

L. Richard (Paris) with M. Rousselot

"Mr. Quinn asked about the deburring of small instrument parts. This is a real problem because dimensional tolerances are usually quite severe and not much is allowed for removal. In addition, each part must be individually racked in order to deliver the proper amount of current to it. We had a case of some very small pinion gears. These had a shaft of about twenty thousandths diameter with an outer diameter on the gear of less than a quarter of a thousandth. These were electrolytically deburred to remove the burr left by the milling cutter. Each individual pinion was racked separately. The additional cost involved was offset by the advantage in this particular case of the freer running of the pinions. They had to be matched afterwards and this added to the cost, but still the overall result favoured the use of electrolytic deburring.

"M. Chambaud asked about the electropolishing of hard chromium or heavy nickel. Hard chromium can be electropolished to make it become lustrous, but then we introduce an appearance comparable with coarse chromium plate, because the electropolishing treatment is similar in effect to the anodic treatment to produce coarse chromium. Heavy nickel can be electropolished. In fact, electrodeposited metals have very much finer grain sizes than wrought metals. They are much more homogeneous and more easily electropolished.

"Mr. Tidswell asked for information about the electropolishing of sterile silver. This metal is being electropolished by one of the large silversmiths in America in a cyanide type of solution. The amount of sterling silver electropolished is considerably less than the amount of plated silver which is electropolished. The electropolishing removes some silver, but it is recovered as a cathodic deposit of

silver which is reusable. The overall loss of silver is considerably less than if it is buffed on buffing wheels according to the usual practice.

"Dr. Hoare asked about the relative brilliance and smoothness of electropolishing versus chemical polishing. In general, electropolishing will give a smoother surface and, because of that, what appears to be a more brilliant surface.

"The fine high-quality cold rolled surface of the fine grain material responds almost equally well to both methods. This means that where the investment for electropolishing equipment would be considerable, and the production of rather brief duration, chemical polishing would probably be preferred.

"May I, in conclusion, make a comment on cleaning which has to do with electropolishing? We have used electropolishing as a part of the cleaning operation principally and not for finishing. In this case, five steps have replaced sixteen steps. These five steps would be: electropolish, rinse, alkaline clean, rinse, acid dip and nickel plating. This would be with bright nickel followed by chromium. The sixteen steps formerly were: three cleaning operations, followed by a rinse and acid dip, a rinse, another clean, another rinse, another acid dip, rinse, cyanide dip, a copper strike plate, rinse, acid dip, rinse and nickel plate. All these steps were needed because of the unusual nature of the drawing compound used. At one stage we had 5,000 parts left in storage and to my knowledge they are still there after ten years."

THE PRACTICAL ASPECTS OF PLATING

BY DR. T. G. COYLE
Vice-President, United Chromium Inc., New York, U.S.A.

THE practical qualification here connotes a certain disrespect for the theoretical. I expect that we shall have little time for discussion of what really goes on in the plating bath, but that we shall discuss rather what the plater must do to get that work out on schedule with a minimum of production interruption and a minimum of inspection and rejects.

There are such matters, for example, as how to lay out the plating department and to select the equipment to go into it—fully automatic, semi-automatic or manually operated tanks; the type of D.C. power to use; the choice of materials of construction, particularly with regard to vat lining and material and the effects on the solution they contain, as well as their economic life. Similarly, there is the question of the handling and treating of equipment such as pumps, and the heating and cooling facilities for temperature control. The practical aspects of the foregoing phases of plating would support a full paper.

Coming to the plating operation proper, the practical requirements, of course, are to get the work covered, the plate to adhere and to be of satisfactory appearance, thickness and uniformity to pass inspection. All this involves attention to cleaning treatments and requires careful plating bath make-up and maintenance, proper jigging and the care of jigs, and control of current and current distribution. It also calls for co-ordination of one plating operation with another where multiple coatings are applied, with an eye to how the result of one operation can somewhat obscurely affect the results of others.

On the left, Adolpho Stein (Milan) with H. Silman

Dr. T. G. COYLE answered questions brought out in the discussion. "In reply to Mr. Wallbank, we try to get the raw material from the mill in as good condition as possible. The plating procedures are common to copper and nickel plate, especially in recent years, when these has been conservation of nickel and a substitution of copper to take its place. The processes generally used are cyanide and pyrophosphate. I get the impression that there is not full appreciation here of the extent to which the pyrophosphate bath is used commercially in the U.S.A. It is used very effectively, along with a variety of cyanide baths, including bright cyanide baths.

"With regard to barrel chromium plating, while it is not very widely used, it is used very substantially, and those people who use it tell me that it is used very successfully for small parts, such as screws, business machine parts, clock and watch parts, and so on. In some of those plants some parts which otherwise would not be chromium plated are plated in chromium plating barrels.

"I think that the difference in practice in regard to barrel plating consists mainly in a more rigid inspection standard here. In the U.S.A. the purpose, where barrel plating is carried on, is to have such a quality that following inspection is virtually unnecessary. There is no separation of good work from bad. The poor work is down to 1 per cent., and it does not pay to try to separate it.

"Mr. Tope asked a question about crack-free chromium, and emphasised particularly the fatigue properties. It is not represented that the crack-free plate has any better fatigue properties —in fact, it has not. This gives an interesting sidelight on some of the earlier theories as to why chromium plating caused early fatigue failure—namely, the so-called notch effect attributed to the microscopic cracks in the chromium plating. In the plate which has no cracks the fatigue effect is about the same, which I think belies the conclusion that fatigue failure is attributable to cracks in the chromium plating. I think that the crack-free plate will have its principal application in regard to corrosion protection. It is so early in the development experience of the plate that its full potentialities cannot be well predicted, but it does give better corrosion protection, both in decorative applications in thin deposits and in heavy deposits.

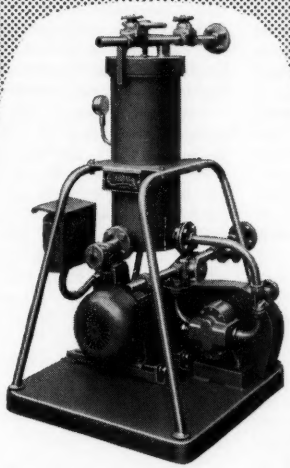
"Mr. Walker asked about the current efficiencies in the S.R.H.S. bath. They depend on the conditions of current density and temperature, and I think it is easier to reply by reference to the straight sulphate bath. They are 20 per cent., 50 per cent. or even higher relatively than the efficiencies in the ordinary sulphate bath. Filtration, about which Mr. Walker also asked, is not a general practice, but is exceptional. It is done in some places, but it is not generally recommended. Some people prefer to do it for one reason or another, but it is not a general American practice. As to the question about the use of the S.R.H.S. solutions on heavy deposits, one of the most important installations that we have is for depositing heavy chromium for wear resistance and for special applications—corrosion and so on."

BRIGHT PLATING WITH METALS OTHER THAN NICKEL

BY DR. R. B. SALTONSTALL
Udylite Corporation, Detroit, Mich., U.S.A.

THERE is actually not a great deal of difference in the practice of bright plating metals other than nickel between this country, the Continent the U.S.A. I will very briefly refer to some solutions that are in use for some of the metals other than nickel which are bright plated, and this review will perhaps serve as a starting point for the discussion.

The first one we think of is copper. Copper is plated on steel, on zinc based die casting and on brass, frequently as the strike. The three types of solutions for plating copper with varying degrees of brightness which are mostly used in the U.S.A. are cyanide baths, hydrophosphate baths and acid sulphate baths. Various wave forms, such as periodic reversal, are used to a considerable extent, particularly on the cyanide copper processes. There are quite a considerable number of proprietary bright and



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high-speed cyanide copper plating baths in use and these, when properly operated according to the recommendations of the makers of the proprietary baths, will give very satisfactory results.

The other two metals which I include principally in this group are zinc and cadmium. I mention zinc first because there is no question but that it is used to a much larger extent than cadmium and undoubtedly this is largely because of the very appreciable difference in the cost of the two metals. At the present time the price of cadmium in the U.S.A. is slightly under 2 dollars a lb. So it still cannot compete in any way with zinc so far as the cost of metal is concerned.

Most of the processes used in the plating of zinc and cadmium are cyanide processes, and again we have rather a large number of excellent proprietary baths and addition agents for this purpose.

In conjunction with zinc and cadmium, bright dips and chromate conversion chromings are used quite extensively. Most or all of the zinc and cadmium plated in the U.S.A. is plated bright, whether it is needed or not.

The other two metals which I might mention briefly, are silver and gold, which are at the present bright plated. Again, there are some proprietary processes for these. I am not completely sure about the extent of their use, but from what I have heard they are operating quite satisfactorily.

In reply to questions raised, Dr. R. B. SALTONSTALL said: "Dr. Fischer asked about finishing after bright zinc plating. I assume that he meant the chromate treatments and bright dips. A great deal of the bright zinc that is plated in the U.S.A. is bright dipped in some sort of solution which actually does some chemical polishing on the surface. One of the very common solutions which is used appreciably is a weak solution of nitric acid. The function of such bright dipping is simply to improve slightly and perhaps to equalise the lustre over the various current density areas of the deposit. We plate zinc with varying degrees of brightness, and the economics of the matter enter quite appreciably. One operator may prefer to put less money into a proprietary zinc brightener and then use a chromate type bright dip—frequently a two-stage dip in which a coloured chromate film is formed on the article—and then to decolour it or bleach it in a solution of a weak alkali. In fact, some find it possible by simply operating a zinc solution of very high purity without any proprietary addition to use this two-stage chromate type of bright dip and bleach and to obtain highly satisfactory results.

"M. Blöchlinger asked about the chromate dipping of zinc in relation to soldering. I am not familiar with very many applications in which we use zinc plate extensively where it has to be soldered. The radio and electronics people prefer either cadmium or the relatively new tin-zinc alloys which we shall hear more about.

"Mr. Wallbank asked about the best method for chrome plating of steel pressings, as far as economy and practicability are concerned. I am familiar with a rather large plant which is producing bumper guards, and I will briefly review the kind of processing used there.

"Generally speaking we clean cathodically. Then we clean anodically. Only a slightly warm rinse is used between these two cleaning operations. After the anodic cleaning, we rinse, and give it a rather short immersion in sulphuric acid, 10 per cent. to 15 per cent., and then rinse again. Sometimes in the sulphuric acid a little smut is raised, so it goes into still another rather strong anodic alkali cleaner. After this, there is again a rinse; and then it is given a very short dip in hydrochloric acid, which is rather strong; and then we rinse thoroughly, and put it into a rather low *p*H nickel strike. This nickel strike may be composed of something like 16 oz. per U.S. gal. of nickel sulphate and the same concentration of nickel chloride, 3 oz. of boric acid and about 4/10ths normal hydrochloric acid. After the nickel strike, which is continued for about 4 mins., we transfer it to a bright nickel solution, and we take special pains to make sure that when the work enters the bright nickel solution it is already cathodically charged. We have special electrical sliding contacts to make sure that we do have a strong cathodic charge on the work when it enters the bright nickel plating

solutions. After bright nickel plating for a length of time, to put on the nickel that we can afford to put on that particular item, we rinse it twice and then transfer the entire rack directly to the chrome bath, and it is chromium plated in the conventional manner.

"The only thing that I know that will help appreciably in this manner of getting a proper tolerance on threads (I am now speaking on cadmium or zinc) is to use a solution with a rather low metal content and a rather high cyanide content. We find that this tends appreciably to improve the distribution of plate between the low and the high current density areas Our plating solutions do have very definite limitations, and all we can do is to equip ourselves to take the best possible advantage of these solutions, and we simply have to let it go at that.

"Mr Frenkel asked about tin plating being included in the list of metals other than nickel. I do not know of any satisfactory addition agent which makes it possible to produce bright tin coatings from the alkaline bath which is most consistently used. It is not uncommon to brighten electrodeposited tin coatings by heat flowing in exactly the same manner as the tin coated strip is brightened by heat flowing. I believe that there is one bright acid tin process which is the subject of certain patents in the U.S.A., but I am not personally familiar with its use.

"I will answer the first part of Dr. Hoar's question and leave the second part till later. He asked about the types of wave forms that are preferred for copper. I think that probably the best known is the periodic reversal. There have been a large number of variations as regards current densities, cathodic time, cathodic current density, etc. What are called the sacrificial cycles use a great deal more anodic current in proportion to the cathodic than do the less sacrificial cycles. By using more anodic current, of course, better levelling, smoother, brighter deposits can be built up to greater thickness, but the matter of electrical efficiency again enters into the picture.

"Mr Smith asked about the mechanical aids that are used in bright copper plating and also about air agitation. When air agitation is used, certainly continuous filtration and diaphragming are quite essential, and in the bright cyanide copper installations, which I think are giving the most consistently good results over continuous periods, diaphragms and continuous filtration are being used.

"Dr. Springer asked about the types of solutions used for bright copper plating. Some of the processes which we call highest bright cyanide copper use Rochelle salt or similar materials; others do not. Quite a good deal of copper plating is done with solutions containing Rochelle salt and no brightener."

Dr. M. B. DIGGIN answered a question on bright silver plating for Dr. Saltonstall. He said that in America most of the dull plating solutions were being converted to bright silver plating because of increased brightness, savings in finishing cost and other factors. Now most of the installations in America were being used for engineering purposes—the electrical industry, radar and other electronic uses specifically. There was some doubt whether sulphur was deposited, but bright silver had been used inside electronic tubes without causing trouble.

He concluded by mentioning that bright silvers have a 120 Vickers hardness number compared with about 65 for ordinary silvers.

METAL FINISHING EQUIPMENT

BY DR. M. B. DIGGIN

Hansel Van Winkle Munning Co., New Jersey, U.S.A.

Dr. M. B. DIGGIN showed a series of slides of metal finishing equipment used in the U.S.A. In the discussion which followed, Dr. WERNICK commented on the continuing use of motor generators in the U.S.A. compared with the almost exclusive use here of rectifiers for power purposes. Mr. SMART felt that, though much of the equipment displayed by Dr. Diggin was used here, much smaller proportion of our factories had them installed.

Dr. M. B. DIGGIN in his reply to the question said: "Dr. Wernick raised the question of the use of rectifiers

and motor generators. I did not intend to imply that in the U.S.A. we use only motor generator sets. We use a tremendous number of rectifiers. I think that for the smaller applications the rectifiers are more economical to use; but when one comes on to the large power units, such as some of the large automobile companies and steel mills have installed, there are definite cost advantages in using motor generator sets. In the first place, the efficiency of the motor generator set is generally higher and the efficiency, if it is properly maintained, will remain high; and secondly, it has a good power factor rating. If one uses a reactor control with an inductive load on a rectifier, it may bring the power factor down to about 70 per cent. efficiency.

The next question referred to the damage to drop work in the barrel plating plants. It is true that the automatic unloading feature in the particular conveyor that I showed dumps the work out. The castings in this case are being bright cadmium plated and are in any case of rough surface. The fall as they empty out is not very high, and the work is satisfactory as it comes out. There is no gauging through to the base metal, and there is still protection.

There was then a question about the maximum amperage used in periodic reversal plating. I can say that on the new bumper bar plant there is a 10,000 ampere generator on each of the copper plating cells, so that naturally the current is reversed with a P.R. controller.

Dr. G. JERNSTEDT spoke about P.R. plating. P.R. plating represents only one facet—it may be only a small facet—in the overall electroplating field. There is a lot of work to be done in connection with P.R plating. To the best of my knowledge, the process divides itself into two principal cycles. The cycles are in the order of 15 seconds plating and from 3 to 5 seconds, or it may be as high as 10 seconds, deplating with the current adjusted in the reverse direction. That particular type of cycle is used for very smooth surfaces, perhaps in die casting, where there is not very much levelling required and where the speed of plating might be required at a higher rate than for a bumper bar, where levelling is required. For the deposits where maximum levelling is required, we use cycles in the order of 60 and 70 seconds plating and 45 to 75 seconds deplating. We have in one installation a cycle in which the deplating time is longer than the plating time—which confused and amazed me when I first started plating. Of course, we use much lower current densities in the reverse direction, and under control conditions we are able to get unusual levelling. We think there is a future for P.R. plating."

A NEW TYPE OF PRIMER FOR RESISTANCE WELDING

BY A. J. ELLEMAN AND N. D. P. SMITH
Imperial Chemical Industries Ltd., Paints Division, Slough, Bucks.

Mr. H. MASON opened the discussion by congratulating the authors on a difficult piece of research work on something which could be of value to the motor industry. However, the biggest possible drawback was likely to be in the cost of the new process. Dealing with contemporary priming methods he said: "In most motor-cars today, they are welded together by pure sheet metal with no protection, and most cars in the big volume class are protected either by rotodip or the slipper bath process, both ideas being aimed completely at enveloping all the welded structure in a corrosion resistant paint material which will also act as a primer. Our experience is that if you slice up bodies treated in that way—primed by complete immersion after welding—you find that the primer completely envelops all the joints and has permeated into all mating surfaces. That is an economically sound process. The type of primer is sound, the bath stability of the primer is good.

"In order to be economic, this primer has to cope with those conditions. What would the procedure be? With a motor-car, we should have completely to prime all the individual panels and stove them before assembly. The body will not be the body in white but the body in the welded primer. That means that three vital qualities are needed in the primer. First, we must have good

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bath stability. We can tolerate only a minimum of settlement. Secondly, that type of primer must be proven from the point of view of corrosion. Thirdly, it must be economic. Immediately we play around with nickel powders, I am afraid the cost is prohibitive. The motor-car industry is exceptionally competitive and such a primer as this has to face what the paint industry is now offering in terms of dipping or spraying primers which are capable of penetrating all the little interstices of a motor-car.

"I welcome the chance of reading this sort of paper because the need for welding primers locally, as distinct from generally, will fall into line with them. By that I refer to joints half-way up a body by which you can spray on a local strip on either side and stove it. In that connection, such an advance would be exceptionally useful, but when it is a matter of all-over painting, the very serious disadvantages which I have mentioned have to be overcome."

Mr. R. J. BROWN questioned whether or not a coating of this type would have adequate adhesion and ductility. He referred to the fact that micrographs show the pigment of the normal paint or primer in the form of discreet particles, but the metallic additive or primer of this ferro-magnetic material is the matrix. That would completely destroy at least the ductility of the paint, if not also the adhesion.

He went on: "Zinc dust welding primers are used in the motor industry and the company with which I am associated use them for the welding of the floor sections. We consider that they are valuable. Although one hopes that in subsequent phosphating and dip priming there is adequate conversion of the mating surfaces by capillary action, I am not sure that the hopes are always fulfilled."

He felt information was needed on the effect of the nickel primer on the fatigue properties of the welded joints. He asked whether they had any information on the corrosion resistance of steel panels coated with these types of primer in an accelerated corrosion test or normal weathering test.

Mr. ELLEMAN said in reply: "As far as we can see, the addition of nickels has no effect on bath stability. All metal powders settle badly and unless we can get a fine grade of nickel a solution will have to be added to circulation in the dip tank. There is no difference in adhesion and ductility between a nickel-modified primer and the normal primer—that is, the non-welding primer—as far as we can see.

"This has been an experimental idea and extra work will be needed to develop corrosion resistance to a greater extent. We have made no comparison between the nickel-modified and the other primer."

INFRA-RED STOVING FOR PAINT FINISHES

BY J. TOLE, SAVART, AND L. HULIN
Société Anonym des Automobiles Peugeot, Paris

MR. L. G. CONNELL disagreed with the author's comments on paint films and infra-red radiation. "If you take a piece of polished aluminium, paint one end with ordinary pigmented paint and leave the other end unpainted; and put the panel into an infra-red oven, you will find that after 15 to 20 seconds you can comfortably hold the unpainted, polished end but the painted end is too hot to touch. I suggest that this means that the paint is a good absorber of the radiation; absorption is taking place in the film and the metal underneath is heated through the thickness of the film." He continued by mentioning the sheathed wire element trough type of electro-radiant heating oven which are popular in England because of their robustness in comparison with the lamp type oven.

He went on: The authors have done a great deal of successful work in connection with stoving of paint on motor-car bodies. When I received the paper, I turned up results of some work which we did at the G.E.C. research laboratories eight or nine years ago on the same subject. The first slide shows the type of sheathed wire element used here. The next slide shows where the thermo-couples were attached to the car body; the curve

on the right shows the temperatures which were recorded in different positions as the body passed through the lamp oven. In selecting positions for these thermo-couples, we tried to select points showing extremes of temperature. The temperatures are shown not for all points but only for those giving the highest and lowest temperatures. With a body travelling through the oven, different parts reach their peak temperatures at different times. One or two of the curves are very low; the lowest is the thermo-couple on one of the door hinges. This is heavy metal, there is a greater mass to heat and it does not reach the same temperature as do the lighter parts. The curve above is of thermo-couples fixed inside the door shuts. The highest curve is of metal in the centre of a door panel and the next two curves are for the rear face of the boot.

"Those top curves show that we were successful in dealing with the problem of how to heat surfaces more or less at right-angles from the direction of radiation. We were in trouble with the heavy door hinges and the door shuts, and with the paints at that time available it was thought that the spread was too much to expect any paint to give good results. That was largely why the process was not followed up here at that time.

In reply it was said the problem of the thick parts of the metal was the same in all kinds of oven. In the very long stove there was a lower temperature difference. In the Peugeot body, the difference between roof and door was only 35° F. It was a question of length of stove and orientation of lamps. If the lamps were perpendicular the difference was higher. The lamps must be at 45°—in two directions.

MR. M. V. MOULE expanded on some of Mr. Connel's remarks about the infra-red lamp. He disagreed that emitters with the highest possible temperature should be used for all stoving applications, saying that, in his experience, there was less colour discrimination with the longer wave lengths produced by a temperature source in the region of about 700-800°C. The longer wave lengths produced by the present best-known radiant heat sources had a wider tolerable range of application than the shorter wave lengths, considering all the associated factors.

He continued: "The authors rightly attribute great importance to the ambient temperature of the infra-red oven as a factor affecting both the heating up time and the heat losses from a body during the holding period. It therefore seems to me fundamentally wrong not to use thermal insulations in order to conserve the convective energy within the ovens. The authors appear to have concluded that thermal insulation is not a practical proposition in conjunction with lamps. In practice I have found that the energy transmitted by convection is a most useful and important component in the heating system. Convected energy smooths off the temperature g r a d i e n t s which are inevitable in practice because of the complexity of the shapes which have to be heated.

"The authors have endeavoured to use the convection component by introducing air from behind the lamps. This practice is bound to create temperature-produced stresses in the glass envelope, and it would be interesting to learn whether the authors have experienced a higher mortality rate in the lamps when this method is adopted.

"The authors comment that oven structures required for lamp procedures are very simple. That is always a most desirable objective in good engineering practice. But I cannot help feeling that in this context a virtue is being made of a necessity. While the lamp may be ideally suitable for some cases, there are few applications where the tubular element, due to the ease with which it can be manipulated into almost any shape, will not serve equally well. Since this method can afford many advantages, such as robustness, low maintenance costs, selection of the most suitable temperature and ease of infinitely variable control, it would be interesting to know whether the authors have investigated the tubular sheathed element and panelled sources of radiant heat which are generally available in this country before they have come to their conclusions."

MR. A. A. B. HARVEY, replying for the authors said: "The authors tell me that it is possible to provide

efficient insulation even in a lamp oven but that in their experience they obtain a sufficiently high efficiency without doing so. In the last 12 months I have seen the Peugeot plant and the highly-polished aluminium insulating casing around the oven which probably acts as a very good thermal insulator, even though they use no lagging of any sort."

MR. H. SILMAN criticised severely infra-red heating. He said: "The infra-red heating process was originated in 1935 when a type of construction was introduced by which lamp units travelled with the bodies right through a long tunnel, and in that way a degree of rapid stoving was obtained which at that time was considered pretty good. The Ford Motor Co., I believe, with possible exceptions of a very minor nature, will have nothing to do with the process to this very day."

Mr. O'Reilly interjected that the reason for Fords reluctance to use this process was primarily financial—infra-red cost roughly seven times as much to heat with as gas. However, they had about seven installations, three or four of which were of the radiant lamp type. Because of the speed of erection they were useful for coping with sudden increases in production in a way which was impossible with gas-fired ovens.

Mr. Silman continued by giving an example of a firm which installed infra-red heating in the summer without insulation for the rapid drying of jerry cans. They forgot that the cans were losing heat all the time, principally by convection, and that the rate of loss of heat is directly proportional to the difference between the air temperature and the can temperature, so that in winter the cans were found to cool as quickly as they were heated. Possibly it was because of climatic conditions that insulation was not required in France, but insulation would undoubtedly give a much greater degree of heating.

The author stated "In Peugeot we have 14 minutes for the primer and 18 minutes for the enamels. The beginning of the stove is 60° C. per minute and the life of the lamp is about 5,000 hours."

The Chairman added that for certain applications, such as dry-off ovens, they used lamps rather different from these, with Pyrex globes to prevent breakage.

MR. WILLIAMS added his criticisms to those of Mr. Silman: "I have had considerable experience of both the infra-red lamp and the tubular sheathed element and can speak with some authority on plant installations and their uses in many industries. Inherently, the lamp is of fragile source with delicate filaments and vulnerable glass envelope. It must suffer a high mortality rate on the production lines, with correspondingly high maintenance replacement rate. Generally, lamps are wired in series, and if one lamp fails two lamps will be out of commission. They are a point source, requiring careful design of the contour of the radiant bank to ensure even radiation on a particular section of object. The lamp has little convective effect. Heat control is difficult. It is generally achieved only by switching lamps on or off, by a multiple wiring system to change from two to three or four in series. This is a very coarse method.

"With the tubular element these disadvantages are all overcome. First, it is far more robust than the lamp for a long trouble-free life. Secondly, it will withstand excessive vibration and rough usage. Thirdly, it is a linear source as opposed to a point source and if necessary can be bent to any desired contour. Fourthly, in addition to radiant source it has some convective effect which is so valuable in the oven. Fifthly, due to mass and inertia its temperature can easily be controlled, giving a vastly improved temperature control in any oven. Sixthly, the tubular element is usually mounted in suitable troughs having anodised aluminium reflectors which require little cleaning and no polishing.

"Due to the fragility of the lamp, many car manufacturers in this country have hesitated in the past to use the lamp for any serious stoving requirements, but this does not apply to the element and many of those car manufacturers are using the element to advantage."

DR. R. HOFFMAN referred to the interesting work carried out in the Volksvagen factory at Brunswick, where they have adopted a mixture of infra-red and convection so that they

are able to reclaim a substantial quantity of their solvents, which in other plants are left.

He continued by talking of Siemens experience: "I have seen installations working on refrigerator bodies running on gas firing. Siemens are electrical people; we do only small articles. We tried lamps—on a small scale—and ran into serious trouble due to focusing; and we gave that up altogether. We got fairly consistent results with the tubes but we gave them up in favour of the tubular type of furnace about 700 mm. dia., inside which the radiation is by spiral heating elements, outside the tube, insulated towards the workshop. We could not avoid using some forced air. We are pushing down from the top at the rate of about 2-2·5 metres per second. We have in the stove two different ventilator systems—one pushing in air from the top along a long tube and passing it down all the way along the tube from the perpendicular. The air is taken off at the bottom by a second ventilator. In this type of oven we have experienced no trouble stoving parts up to 15 kg. which we can bring to 150° in 6 minutes, or with similar treatment with frameworks or teleprinters. The explosion and fire hazards are only from spilling."

Concluding the discussion, Mr. Logan commented that the deciding factor in this argument was economic and that, in France, electric radiant heat was considerably cheaper than fuel oil and gas.

AUTOMOTIVE ORGANIC FINISHING

BY JAMES T. O'REILLY
Ford Motor Co., Dearborn, Mich., U.S.A.

Mr. R. J. BROWN asked questions about performance testing of Ford finishes, the reasons for the preference of red oxide as a primer, the Florida exposure tests and American co-operative work on accelerated testing.

In his reply Mr. O'Reilly, dealing first with performance testing said: "I might say that what the Ford Motor Co. are going through is perhaps what General Motors went through many years earlier in the United States. It is a problem which may face you on a somewhat smaller scale. In the last five years the Ford Co. have changed from a highly centralised company to a highly decentralised company. We have the Ford Division, the Mercury Division and the Lincoln Division. They are all separate and they are all conscious of their new found freedom.

"On the other hand, we have a central staff, of which I am a part, which is a co-ordinating agency. One of our functions is to supply them with specifications and to ensure that the left hand knows what the right hand is doing. Our main practical means of doing that is a system of committees.

"We have set up a system of specifications which are intended to be performance specifications. We have one on interior quality enamel, one on exterior quality, one to do with Lincoln and Mercury quality and the to do with Ford quality—and the difference is hypothetical. One is supposed to be polished and with the other no polishing is required. In practice, neither is polished.

"There is a scope which defines the general type of the material and the quality is briefly defined. There is a requirement that the weathering resistance be comparable to the approved standard after one year in Florida. By Florida, we mean South Florida, in the Miami area. There are details on the preparation of the panel. The pigment must be balanced. These values may be of interest: all metallic colours, 46 per cent. minimum; dark colours, 47 per cent. minimum; light colours containing from 80 to 95 per cent. titanium oxide pigment, 52 per cent. solid; light colours, 54 per cent.; pure chrome colours, 52 per cent. These enamels were adopted on the Mercury in 1953 and on the Ford in 1954. I hope you will excuse me for talking about the Ford Motor Co. all the time, but I know most about it and it is generally typical. We also have the heat stability test, the hardness test and so on.

"I could also give you a priming specification. A typical composition which has been found satisfactory is pigment 52 to 56 per cent.; and of that 30 per cent. is ferric oxide, 5 per cent. zinc sulphide and 65 per cent. is inert.

The vehicle contains 100 per cent. alkali. The vehicle which contains 44 to 48 per cent. is 100 per cent. aldehydemine oil. The solids are aromatic.

"As for the question about oxides *versus* an inhibitor, iron oxide is an inhibitor. These things are a matter of degree, and I think cost and necessity largely dictate our choice.

"I was asked how we backed up Florida exposure. Service is, unfortunately, the real answer, and if we find that there is any conflict between our Florida exposure and our service experience, of course, service experience has priority."

Mr. N. E. COOPER asked what was a good degree of maintenance of phosphating plant.

Mr. O'Reilly replied that Fords had an elaborate specification which experience had taught them should be meticulously obeyed down to the last detail. Refering to Briggs he said: "I saw a useful gadget at Briggs—it may be general over here but I had not seen it before—which consisted of an ammeter indicating how much resistance is in the line. We have put pressure gauges on each header and it is simple to walk down the lines and glance at these dials. If the pressures are not adequate, that is a warning that something is wrong."

"We spell out that the phosphate coating panel shall be of such-and-such a size, and the primer which is used is the same as is used in production. The type of top coat and that sort of thing are all defined in the specification. There is a salt spray test; we require a 250-hour salt spray resistance—there is a square panel and a scratch diagonally. We have an impact test, we send it to Florida for exposure tests, and so on."

Answering Mr. E. E. V. Sharpe's question about the use of zinc chromate primers in Ford's Canadian plant where there is no control on its use for protection from dermatitis, Mr. O'Reilly said that it was not being used, but that, if they felt there was a need for that type of primer, the present spray baths would make it tolerable from a health point of view.

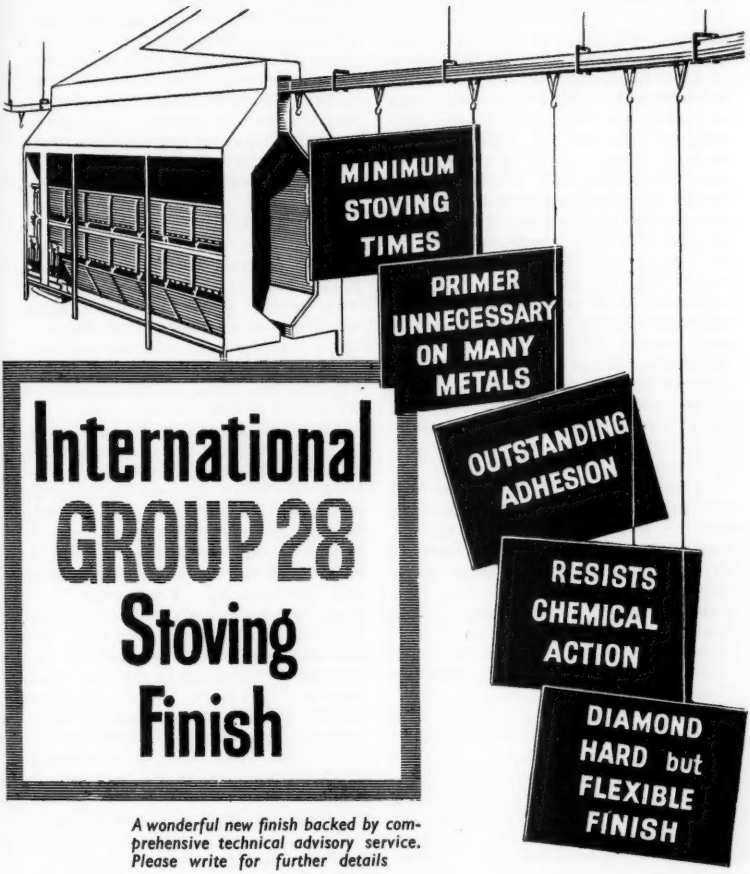
Asked by Mr. COOPER what America considered to be a double coat of lacquer. Mr. O'Reilly said: "By a double coat I mean one almost immediately followed by another, and usually in a different direction. It is a difficult thing to define. The classical idea used to be to put on one coat, quickly followed with a frost coat, and then a time interval and another coat; there might be a minute's delay and then some more. The only way we can adopt is to ask how many manhours are expanded to put the paint on. When you talk about how many coats, you have to consider how much overlap. In one of our plants on enamel I saw one booth painting one type of body using two coats and 100 yards away there was another booth and another group painting another body style putting on four coats. They both wind up with the same figures. But what does it mean? It is the function of the speed of the gun among many other things."

ORGANIC FINISHES ON ELECTROPLATED COATINGS WITH SPECIAL REFERENCE TO ADHESION

BY E. C. J. MARSH, B.Sc., F.R.I.C., F.I.M.
Standard Telephones and Cables Ltd., New Southgate, London, N.11

Dr. S. G. CLARKE asked whether the author could make any recommendations about the adhesion problems of electrodeposited lead. He thought that the tests used by Mr. Marsh—bending, scratching, scraping—did not give such valuable information about adhesion as research performance data determining the pull to detach the coating from a certain area of the metal. He continued: "The author makes the important point that the adhesion of paints on some electroplates is not a constant quantity but deteriorates with time. There is the corrosion problem which he mentions in the form of some undesirable product between the paint and the metal surface. In the paper he instances a case of flaking of paint from the zinc; he noticed the corrosion product adhering to the inside of the flake. Did he observe the zinc coating underneath to see whether it was free from corrosion product or whether it had some corrosion product in it? I am inclined to think that in this case the break occurs within the layer of the corrosion product.

Turning from bad adhesion to



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good adhesion, I agree with him that for the most of the electroplates some chemical treatment is desirable. It is not at all easy to explain how the desired effect is produced but could I induce the author to speculate a little more on what are the criteria of good adhesion? Is it, for instance, that chemical treatment has to produce an inert film on the metal which stops the spread of corrosion underneath or is it the etching effect produced by chemical treament or a combination of the two?

Dr. WERNICK spoke of Mr. Marsh's use of an etch primer: "He has been talking largely of the two-pack primer. Many would be interested to see a development in the direction of a one-pack primer which would enable the possible development of this process in cases where paint dipping is a continuous operation.

"I am interested to know what sort of preparation the zinc coating received, if any; and if there was no preparation, has Mr. Marsh been at all concerned about the time which elapses between the job being zinc plated and going to the primer. I can imagine certain complications arising from the production of surface oxide layers on the zinc coating, possibly affecting the adhesion.

"Those who are burdened with zinc problems know that we run into certain abstruse phenomena such as spotting out. That must have some effect on the problem of adhesion when a paint coating is interposed. I am rather intrigued by this step towards etch primer plus paint. Many years ago, when Mr. Marsh and I were close colleagues, the industry was doing very well with aluminium paint finishes. I wonder why these finishes have apparently been abandoned."

Mr. MARSH, replying to Dr. Clarke's query on lead, said: "I have no experience of paint coatings on lead; in sealed components such as condensers and transformers, where about 60 per cent. lead is involved, the etch primer is satisfactory. In one or two instances where we have had to finish lead we have used this primer, not for any merits but because lead is difficult to paint. We have had no adverse comments."

He continued in reply to the other question: " There are a number of suggested systems to measure paint adhesion, in my opinion nothing very practical or sound at present. Perhaps one of the paint experts would reply to that question. The next question was whether the break occurs in the corrosion layer or on the zinc strata; and I think it occurs in the corrosion layer but I should not like to be too certain.

"One question was why we got such good adhesion on brass or copper, because you cannot expect phosphoric acid to etch brass in the same way as with zinc. It makes one wonder whether the chromatic acid helps to cause reaction between the phosphoric and the copper-rich surfaces which enables that band to be formed. A lot of that is speculation.

"It is important which etch primer you use because, due to the complexity of these reactions, there must be an optimum balance between all ingredients, particularly between the percentage of water present and the chromium ions which are formed in relation to the base surface to which you are applying. You cannot hope to get the best results with one primer for all types of surface. We have used one universally and by working with various suppliers we found one which suits and have been virtually free from trouble it is of our own making. When you mix ingredients you have to mix in the right proportions and they must be thoroughly mixed and to be used in a stated time.

"Coming to the one-solution primer, I do not know of any single solution in any way comparable with the two-solution primer, and, because of the complexity of reactions which occur, I am not too optimistic that such a satisfactory single solution primer can be used.

"On spotting out, anything alkaline is detrimental to any paint coating. Spotting out is due to increased alkali and that is bound to give poor paint adhesion. Aluminium powder paints have shown better apparent adhesion to zinc plate than any other type of paint, and we have used them to improve adhesion, as our primer, but the effect is not permanent and if you go on to the site after a few years, look at the installation to see what the adhesion is like. there is none."

THE RESISTANCE OF SOME CAST AND PLATED SLEEVE-BEARING MATERIALS TO CAVITATION EROSION

BY R. A. SCHAEFER, J. F. CERNESS AND H. A. THOMAS
Clevite-Brush Development Co., Division of Clevite Corporation, Cleveland, Ohio, U.S.A.

MR. FORRESTER spoke of the increasing speeds to which bearings are subjected. He went on to say: "Dr. Schaefer mentioned that many bearings are subjected to loads which vary from 3,000 to zero within a fraction of a second. It is also possible for cavitation to occur in constantly loaded bearings or in bearings which are in machines always subjected to positive loads, possibly because small volumes are trapped between the surface roughness and as the trapped volumes are released a local pressure can be created.

"Looking at the results there does appear to be general correlation between hardness and strength on the one hand and resistance to cavitation on the other, but there are some curious anomalies. For instance, there is an interesting difference between two different copper-lead alloys one with one and one without silver, and I should like to know whether Dr. Schaefer considers the difference between these two materials is significant.

"One of the great points about the mechanism of these phenomena is that it seems to us that it might be connected with the question of fatigue."

Dr. R. A. SCHAEFER replied: "As far as the question of fatigue and cavitation erosion is concerned, there is no question that in severe cases fatigue and cavitation erosion are two different phenomena. I cannot understand the statement that there can be cavitation erosion without pulsating load. Hundreds of examples clearly indicate that.

"We have not done sufficient work definitely to show any relation between cavitation and chemical susceptibility to erosion. We think that there is some relationship but it is inexplicable at the present time."

TIN-ALLOY PLATING: AMERICAN EXPERIENCE

BY FREDERICK A. LOWENHEIM, PH.D.
Metal and Thermit Corporation, Rahway, N.J., U.S.A.

DR. J. W. CUTHBERTSON referred to the considerable advantages of higher speeds achieved by Dr. Lowenheim with his substitution of potassium salts for sodium salts in the original Tin Research Institute's tin-nickel plating process.

Speaking of Dr. Lowenheim's assertion that tin-zinc should no longer be regarded as a substitution coating, he said that compared with cadmium that has not been specially prepared paint adhesion is better. Tin-nickel was now commercially practicable and plants had been running continuously in America and this country for some time. He mentioned a continental application of tin-nickel: "It is a cheap method of producing inexpensive spoons and forks. The blanks are steel and hot-tip tinned for the purpose of obtaining a good, smooth and bright face for plating. Hot-tip tinned steel spoons are attractive although there is a tendency for them to go yellow. However, by giving them a flash coating of tin-nickel a good finish is obtainable and a fairly lasting surface."

He went on: "Returning to the other processes of cadmium-tin, we of the Tin Research Institute have been interested in the claims which have been made in the United States for the high resistance to marine corrosion exhibited by cadmium-tin alloys. I am not qualified to say much on this because it is in the direction of corrosion resisting rather than plating, but I understand from Mr. Brittain that today he has found that fifty-fifty alloys have shown quite extraordinary good resistance to corrosion under marine conditions, in which circumstances they are apparently behaving better than zinc or cadmium.

"Any alloy plating process is bound to be more complicated than a single metal plating process. If the process is to be a success and whether or not it will make headway must, I think, largely depend on how easy or diffi-

cult it is to control. One of the reasons for tin-zinc becoming a commercial process I feel sure is that it is not very difficult to control the compositions of the deposit at the required figure, but more than that it does not matter very much if the composition deviates quite a bit from that optimum. For instance, we generally say there is not much difference in the protective values of tin-zinc coatings when the zinc content varies over the range from perhaps 20 to 30 per cent. so that close control of composition is not necessary and, in practice, one need hardly bother about control. In tin-nickel plating we are convinced that here is one process where the composition of deposit does not vary very significantly. We have reached the stage where we never bother to analyse tin-nickel deposits because we are certain that if they have the right appearance when they come out of the bath they will have the right composition."

Dr. Cuthbertson mentioned the unpopularity of speculum plating in this country and attributed it to the necessity for close control of the composition of the deposit, especially because appearance of the deposit gave no guide to variations in compositions.

Mr. F. A. LOWENHEIM replied: "I would say, in regard to Dr. Cuthbertson's comment on the substitution of cadmium for sodium in tin-zinc plating baths, that this has given us some very good dividends. It would also seem to us that the cadmium bath is less critical in control. The composition of deposit is not as dependent as in the case of the sodium bath upon current density, temperature and working conditions, so we have improved the situation in regard to control.

"I know that there has been some controversy as to whether tin-cadmium alloy is as corrosive resistant as would appear, but it seems to have been sufficiently resistant to have led the armed forces of the United States to use it for some types of naval aircraft. So far as tests on corrosion resistance are concerned, they have been limited to salt spray."

PROGRESS IN TIN-NICKEL ELECTROPLATING

BY A. E. DAVIES, PH.D., D.I.C., A.R.C.S.
Tin Research Institute, Greenford, Middlesex

THE development of the ammonium fluoride type bath was the subject of a question by Dr. PARKINSON, who said that the opinion at the Tin Research Institute used to be that the addition of sodium fluoride to the ammonium fluoride bath gave brighter results. Dr. Lowenheim was of the opinion that it did not matter what type of fluoride was used provided its *p*H was controlled. Dr. Parkinson mentioned the question of sodium stannite fluoride precipitation. In his experience of barrel plating with tin-nickel he had been struck by the considerable amount of precipitate from the original bath in one installation. They had had to change the filters daily. He asked a question on the mechanism of deposition by immersion of tin anodes.

Dr. BLUM asked whether there was a relatively high polarisation to account for the high throwing power.

Mr W. MYER said: "I think that we should regard fluoride baths as being similar to cyanide solutions. The reaction rate of aluminium with HF is many times stronger than with HCl because of the strong complexing effect. I always think of this solution as a cyanide solution. Of course, it has negatively charged ions which go to the anode and not to the cathode, and there must be high cathode polarisation.

"It may have been noticed that there is a critical anode current density and there may be an analogy here. At critical anode current density the anode ceases to function as an anode. What one is getting is an anodic deposition of copper oxide from the solution and not the formation of salt. A steel anode could be used to deposit copper oxide at the anode. I wonder why Dr. Davies did not try potassium fluoride salts."

Dr. F. A. LOWENHEIM added: "On the general question of the deposition of metals from negatively charged complexes, it is not confined to cyanide baths. I think that it is necessary to look at the mechanism of

deposition as something independent of the mechanism of migration. The ions are in the cathode film but how they get there is another story. That probably has something to do with cathode efficiency.

Dr. A. E. DAVIES replied that with regard to the all-ammonium bath, they had operated an all-ammonium bath for up to four or five months and had encountered no difficulties at all. He added: "However, our oxidation rate was not very high so we had to add stannic chloride artificially to bring up stannic oxidation in order to see how it would behave after a couple of years' installation. There will be no trouble until the stannic tin gets to about 60 grammes per litre when the fluoride concentration is high and there may be a tendency to crystallise out. That would only happen after several years operation.

"We have done some work with regard to the immersion deposit on the tin anodes and we have found that it is at a minimum at very high current densities. If anodes are worked at 100 per sq. ft. the wastage is less than 4 per cent. which includes sludge.

"In reply to the point about high polarisation, I can only give the actual figures of the measurement which we have made. There is not much variation in density.

"We have tried potassium fluoride. In deciding upon which alkaline to use we consider the solubility of the various salts. I agree that there is no need for any particular fluoride and that any kind may be used.

"With regard to the question of high fluoride concentration, there is no upper limit except from the point of view of solubility.

A LABORATORY TECHNIQUE FOR THE ELECTRODEPOSITION OF MANGANESE ON OTHER METALS

BY WINIFRED A. BELL, B.A.

Fulmer Research Institute Ltd., Stoke Poges, Bucks.

DR. C. L. FAUST agreed with the author that there was evidence that manganese should protect larger exposed areas of bare steel than zinc, but I thought one could not interpret it that for equal thicknesses manganese would give protection for longer periods of exposure. He said: "Manganese is so much more active that it disappears rapidly as a result of sacrificial protection. As Miss Bell has observed, we also found that in accelerated tests the corrosion of manganese plate on steel gives an appearance as though the steel were corroding. In outdoor exposure the corrosion products of manganese had a different but characteristic colour. The manganese coatings appear to have a weakness at the iron manganese interface in that undercutting occurs. The coating then flakes off. Our experience has been that 0·1 mil of zinc is superior to 0·5 mil of manganese in a hot, humid atmosphere. There is some evidence that this disparity will not be as great in an industrial atmosphere.

"With regard to the differences in *p*H, we have observed that as the Mn content of the solution increases, the optimum *p*H decreases. Jacobs in his electrowinning work on plating manganese from chloride baths observed this also."

DR. SODERBERG spoke of his experience with manganese in the United States. "We started off with copper-manganese alloy (about 2 per cent. copper) because in that way we could stabilise and obtain the gamma phase which is ductile. I should think that flaking might have some relationship with whether it is alpha manganese which is brittle or with gamma manganese which is not.

"We worked with a similar system to that used by Dr. Bell, but we have to use extremely high current density in order to get any plate, and as a result the throwing power is very poor. In my view if manganese is to develop then it will be necessary to develop different electrolytes from those at present used."

MR. LIDDIARD replied. Answering a question of MR. QUIN he said: "We do protect aluminium with manganese and are still experimenting with it. One of the difficulties with manganese on aluminium is, of course, that its appearance is not particularly

good. Aluminium is in a somewhat different class from steel from the point of view of corrosion resistance, and the protection by manganese, although it certainly works, does not give a surface that looks at all attractive. This question of appearance of manganese has been mentioned by Miss Bell, but it is perhaps even more striking than in the case of aluminium. There is no doubt that aluminium can, to a certain extent, be protected by manganese." He continued: "I agree with Dr. Soderberg that if it is necessary to develop a satisfactory technique for ductile managanese coatings we shall have to do something to get away from the brittle alpha, but we consider it important to investigate the pure manganese and we were suspicious of having copper in manganese.

THE ELECTRODEPOSITION OF GOLD AND OTHER ALLOYS BY A NEW METHOD

BY G. E. GARDAM, B.SC., PH.D., A.R.C.S., F.R.I.C., F.I.M., AND N. E. TIDSWELL

Formerly of the Design and Research Centre for the Gold, Silver and Jewellery Industries, 26 Dover Street, London, W.1; present address, Aluminium Laboratories Ltd., Banbury, Oxon. Formerly of the Design and Research Centre for the Gold, Silver and Jewellery Industries, 26 Dover Street, London, W.1.

IN the discussion Dr. HUNT asked what anodes had been employed and queried the statement that a deposit with 8 per cent. gold gave the colour of pure copper. Deposits prepared by normal methods, he said, gave an "18 carat red gold" colour. He would like to see work done on the effect of temperature and agitation on the deposits, such factors must affect speed of diffusion of the ions in the cathode layer and the deposition rate and colour of the gold deposit.

Dr. BAIER thought that the fundamental difference between gold alloy and other alloy deposition probably lay in the fact that one had 2 per cent. alloy in constituents to give range of colours so that for a particular colour it might mean that one had to be within $\frac{1}{4}$ of 1 per cent. of alloy constituents to maintain it.

He continued: "I thought that perhaps that was one of the real snags, that one was trying to control within this very narrow limit of alloying composition, but if we look at the other side of composition required to give yellow or red gold is 3·2 grammes per litre of gold and 12·7 grammes per litre of copper. Therefore, the ratio is 4:1 in the solution and it would seem from that that there is no reason why a small change in solution composition would make a negligible change in the alloy deposited on the basis of work with bronze. It struck me that the real difference is the extremely weak solution with which one is working. What happens is that there is one deposit in the first half minute, a different colour after one minute, a third colour after two minutes, and so forth. The cathode layer changes very rapidly.

"I feel that if one could afford it and used 30 grammes per litre of gold and a quarter of that alloy constituent it would become very much like bronze plating. Something which gave 50 per cent. efficiency would be provided and it would be a question of building up the gold solutions to whatever composition was desired with consistency all the way through. This is really a fundamental method of working with weak solution so that without using large concentrations one can obtain a constant alloy deposit."

Dr. RINKER spoke of his work in this field. He said: "It is feasible to deposit alloys of 16 to 18 carat using copper. Unfortunately it is not a true alloy and it will tarnish. The deposits are relatively smooth and they have all the characteristics of true alloy. One of the difficulties of this method of plating is that the distribution of the gold and the copper varies according to the geometric figure over which one is attempting to deposit, and I think that Dr. Gardam has made an interesting approach in suggesting pulsating current as this might be the means of getting better distribution of the copper and gold throughout a difficult shaped article.

"On the subject of deposits from the bath in the case of copper-gold, I should like to question whether they are not subject to tarnishing. In the United States we are doing a great

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deal to brighten gold plating. It is relatively hard and cannot be called an alloy. The deposits are generally from 99 to 100 per cent. gold, but the incorporation of other metals in the gold definitely gives the deposit extreme hardness as compared to conventional gold.

"There seems to be a great deal of interest in gold plating, particularly in the industral field where the protective characteristics of the deposit are important. As a result the gold deposit is certainly becoming of great interest particularly from the point of view of of industrial applications."

Mr. N. E. TIDSWELL said in reply: "We use stainless steel. If we use gold anode we find that the rate it disappears is in excess of the rate we plate it out.

"As regards colour with 80 per cent. gold, the colour was that of pure copper and it did tarnish. Colours very close to copper were obtained which would last up to three months without any real tarnishing taking place, but once it is copper coloured it tarnishes.

"Variations in chemical composition did not trouble us greatly because the amount of gold we were putting on was very small indeed. It was only a thin colour flash for the cheap jewellery trade. The manufacturer was turning out about 150 gross of small jewellery items a week, and he used an ounce of gold on Tuesday and another on Friday. Copper was put in by the shovelful but excess copper did not matter in the slightest. The amount of silver given in the paper of ·8 grammes per litre is the amount required for normal plant efficiency. It is possible to obtain all colours to red with a low silver content.

"On the question of colour control, we are using a four gallon bath and were doing batches of thirty-six at a time. The variation in colour was so little over a full day's run that there was generally no need to alter the timing mechanism once it was set. Consequently, what the foreman did in fact to control the plant was to check the first batch in the morning for colour, make a small adjustment, check again, and after that he ran on to the second day. If the stage were reached where it got very low, he tended to get too deep a colour on his first check in the morning. He put another ounce of salt in the bath which brought it back to normal and he then carried on.

"With reference to the question of the weak solution, cost was the reason for operating on those figures given in the paper. Some platers operate as low as ·5 grammes per litre and most of the deposit tarnishes after three weeks unless lacquered, but as many of them are lacquered it does not bother them. At around 2 grammes per litre normally they do not tarnish.

"We have not done any large scale research on the question of structure, but this is what we think happens. In the first instance of the impulse all current is taken up by the gold in the cathode layer. Once there is insufficient gold to take care of all the current available, one then obtains silver plating; but there is some gold coming up the cathode by diffusion, and we have found that one still gets roughly 80 per cent. of gold steadily being plated. That layer will continue all the time. The remainder will be taken up by the silver."

RECENT ADVANCES IN TINPLATE MANUFACTURING PROCESSES

BY W. E. HOARE, B.SC.(ENG.), F.I.M., A.I.PROD.E.
Tin Research Institute, Greenford, Middlesex

DR. W. E. HOARE replied to questions rising from discussion of his paper. He said: "DR. PEARSON'S first remark was on the question of the residuals, such as sulphur, phosphorus, nitrogen and so on, in the steel. This does, of course, have a very important effect on the ultimate quality of the tinplate. Even a decimal point after the zero in sulphur can have quite a significant effect.

"With regard to the effect of continuous annealing on ductility and stiffness, Dr. Pearson said quite rightly that normally stiffness and ductility are antagonistic to each other. As stiffness goes up, so ductility goes down. In continuously annealed plate, where there is extremely rapid heating and extremely rapid cooling, one gets conditions that are really much closer to those of normalising, and it is pos-

sible to get a tinplate or a steel strip, for example, which will have a very considerable ductility and at the same time sufficient stiffness to give a very strong article.

"Dr. Pearson was intrigued by the effect of the annealing atmosphere on corrosion resistance—and so am I and so are many other people. The strip out of an annealing plant nowadays comes out so clean that it hardly needs any pickling at all—it just needs wetting—so that the pickling process does not really take off any steel at all; and a pickling process as ordinarily used in electro tinplate manufacture is not sufficient to remove this skin effect which is developed by the annealing atmosphere. It is rather curious that in hot-dip tinning, where not only is the steel pickled but is also fluxed, those two treatments one after the other appear to be sufficient to remove this vestigial effect. Whether it is some form of carburisation, whether it is oxidation at the grain or whether it may be some form of nitriding effect, I do not think is quite settled. Certainly there are some grain boundary oxidation effects occurring when one uses an atmosphere which contains a certain amount of carbon-monoxide which are absent when one uses a process which contains none; but what the exact answer is we do not yet know.

"There were one or two points raised about the possible advantages of the alkaline line. Dr. Pearson mentioned this matter, and Dr. Lowenheim gave some very interesting information which I think really constituted a reply to Dr. Pearson's remarks. Dr. Cuthbertson also mentioned this matter, and he said that he supposed that the operation of flow-brightening where the tin coating is melted might even out or obviate any effects that might have supervened in the previous electrodeposition operation. In point of fact, the flow-brightening process does not obviate the effects. The flow-brightening process itself is affected by what goes before it, and it is affected notably by the chemical cleanliness, if you wish, of the steel base. The alkaline line, other things being equal, does clean itself, the electrolyte cleans the steel base, and therefore gives a steel surface on which the tin can flow and alloy more readily and more completely than the acid line or halogen line under similar conditions.

"Dr. Kayser asked an extremely awkward question, namely, the question about rolling tolerances. Of course, it all depends! If you take one sheet, you have to fix one tolerance; if you take 1,000—and usually tinplates are shipped in packages of roughly 1,000 sheets—then, of course, you can use different tolerances on the average gauge. Before the war, the general tolerance accepted (that is, not as a contract between any particular supplier and any particular buyer, but the general tolerance) was something like plus or minus 10 per cent. With new plant I myself am of the opinion that this could possibly now be reduced to something like plus or minus 7 per cent., and to be on the safe side I would contend personally that probably something like plus or minus 8 per cent. for single sheets might be a fair practice today.

"Dr. Clarke asked a question on the range of coatings now available by the two processes of electrodeposition and hot dipping. The normal range of coatings is from ¼ lb. per basis box to 1½ lb. per basis box. Translated into units that we can all understand, it is from 15 millionths of an inch of tin coat to something like 1 10-thousandth of an inch. You can, if you wish, purchase tinplates up to a coating of about 16 lb. per basis box, or 1-thousandth of an inch. But 95 per cent. of the tinplate produced in the world has a coating thickness ranging from 15 millionths of an inch to 1 10-thousandth of an inch.

"Dr. Cuthbertson rightly said that the alkaline lines do have advantages in that the material can be less expensive. You can handle hot alkaline solutions in unlined steel equipment, whereas for the halogen and acid sulphate lines you must use rubber-lined equipment throughout.

"Dr. Wernick asked about the relative merits of the protective qualities of hot tin, alkaline electro tin and acid electro tin on steel. The corrosion resistance of these various grades are broadly governed by the amount of tin on the plate by whatever process it is deposited.

THE INFLUENCE OF ANNEALING ON THE STRUCTURE AND HARDNESS OF ELECTRODEPOSITED CHROMIUM

BY C. P. BRITTAIN, B.A., AND G. C. SMITH, M.A.
University of Cambridge, Department of Metallurgy, Pembroke Street, Cambridge

MR. G. C. SMITH replied to the discussion: "In connection with the point about the etching of the chromium specimens, it was obvious that in order to get any detail at all from the form of our replica we had to etch the surface. It is not sufficient to examine a polished surface. The detail is revealed in the electron microscope by differences in the thickness of the replica. In order to get the replica detailing freely from the surface, one must have a critical time of etching, but I do not think that there can be any very great effect of the time of etching upon the actual nature of the crystal structure that one sees.

"One or two speakers have questioned the micro-hardness test. The instrument used employs a Vickers type diamond, so that the results are in a way comparable with those that one gets when using the ordinary range of loads that one employs with the ordinary Vickers tester. The actual loads that we used were 10 gm. and 100 gm., and in each case the impressions were measured by using an eyepiece with a measuring scale which was accurate to at least 0·3 of a micron. The results were repeated by different observers and tied up reasonably. There is, nevertheless, this difference that one obtains with the 10 gm. and 100 gm. load, and we are not sure to what that difference is due. I have said that it may be due to the effect of the cracks, but when you are working with a low value of load you cannot get the true hardness of the metal because you are deforming a region of metal within the crack system, and the cracks will have their effect. When you are dealing with a higher load, then if the impression is going to cover a large area of metal, including the cracks, you may get the same value of hardness; but if you work with an intermediate load you may get the effects of the crack system due to a slight movement of metal into the cracks.

"We have not observed any effects such as were described by one speaker, where the hardness decreases for a time and then increases again. It is possible that this may be due to some re-precipitation effect, but in our experiments we have not observed anything of that type. Similar effects are known in age-hardening systems, where on first heating there is a softening, and subsequently there is a further hardness as one gets re-precipitation taking place. Whether that is happening in the case of chromium is very difficult to say."

A QUANTITATIVE ADHESION TEST FOR ELECTRODEPOSITED CHROMIUM

BY C. WILLIAMS AND R. A. F. HAMMOND
Armament Research Establishment, Fort Halstead, Sevenoaks, Kent

MR. C. WILLIAMS said in reply to discussion questions: "It was suggested that our test was not in fact an adhesion test. The work that we have reported, I agree, seems to be work on the properties of chromium, but we have used it on cleaning procedures which have been suspect, and we have been able to evaluate cleaning procedures on the adhesion value which is well below the usual value of 7½ tons per sq. in. In that case, fracture occurs at the substrate chromium interface.

"With regard to Mr. Fry's remarks, I am afraid that we have not determined the thickness of chrome remaining on the shank face of the test pieces plated at 80° C. I really cannot give a satisfactory answer as to why we should expect failure in the first period during periodicity. The position is rather complicated because if one examines the shank face after fracture there is a considerable thickness of chrome right on the periphery

of the shank which is considerably more than the ·404 of an inch; it is of the order of half a thou. on a thou. thick deposit. At the periphery of the of the shank face there is considerable stress concentration and it may be that it is only on the periphery that we are having truly axial loading conditions, because as fracture proceeds radially inward there is deflection of the nickel backing and a form of tearing action.

"Dealing with Mr. Wallbank's query, we have tried proprietary chromium plating solutions, and the adhesion values obtained were of the same order as with standard chromium, within say 10 or 20 per cent. With regard to the suggestion that cracking in the chromium should be minimised, I think that probably the answer would be to deposit it at a higher temperature, probably 80° C. or 85° C., using standard chromium. This deposit would have a lower oxide content and is generally sounder and stronger. You might be able to reduce the temperature of deposition by using a proprietary chromium plating solution. I understand that you might be able to use a crack-free deposit at about 60° C."

THE DIFFUSION OF CHROMIUM AND OTHER ELEMENTS INTO NON-FERROUS METALS

BY R. L. SAMUEL, ING. CHIM., AND N. A. LOCKINGTON, M.A., A.R.I.C.
Diffusion Alloys Ltd., New Eltham, London, S.E.9

MR. R. L. SAMUEL stated in reply to questions: "With regard to the question of boxes which have to stand up to 1,100° C., we are coating at 1,100° C. because it is a very convenient temperature for obtaining diffusions and therefore quicker variations of coatings. It is a practical method that can be used in a laboratory but which we would not think of using in practice. There are such boxes in use, and we are using them quite commonly for non-chromium diffusion, and the order of temperature is slightly larger.

"With regard to Mr. Oswald's question on the stopping off of the diffusion, it is possible to stop off chromium diffusion or molybdenum diffusion, but it is not an easy matter. It can be done and it is successful up to a point, but it is more complicated than treating the whole part. Unless one uses localised methods in applying the heat, which can be done, one does not usually stop off any part unless there is a specific request for it to be done for some technical reason."

THE PREVENTION OF CRACKING IN NICKEL ELECTRODEPOSITS

BY T. E. SUCH, B.SC.
Wilmot-Breeden Ltd., Birmingham

OPENING the discussion Mr. H. A. Manning, speaking of the effect of contaminants mentioned by Mr. Such, raised the question of the effect produced by breakdown of the organic addition agents themselves on ductility and tensile stress.

Mr. Such replied that indications at the moment were that over a long period, when the solution was worked very hard, such breakdown tended to raise tensile stress, and it gives a more brittle deposit. That combined with the brittleness produced by metal contaminants tended sometimes to produce a poor job.

DR. H. FISCHER gave a possible explanation of the diminishing of ductility of the nickel deposits during electrolysis. He thought the cause might be in the nature of the organic brightener. Such brighteners as sulphonic acids and thiores were known to be reduced during electrolysis. Perhaps the secondary reaction of the products resulted in the nickel ions forming nickel sulphites and nickel sulphates. There might be correlation with the addition agents included in the deposits, causing brittleness.

Mr, Such dealt with a question by MR. W. G. L. MILLER on why there should be cracking on fully annealed brass and not steel. He said: "I have done some work on the effect of an undercoat of copper, underneath a bright nickel deposit. It increased the apparent ductility of the top coat of nickel, but I found that taking a fairly brittle organic brightness deposit, the

effect of 1-thousandth of copper was to increase the apparent ductility by only 25 per cent. so that I do not think the effect of two-tenths of a thousandth would be very significant. The only tentative suggestion which I can make to explain why he had cracking with brass was that the distribution of the nickel plate on the brass article was somewhat different from that on the steel. You often find that it is the high CP areas which go down first with cracking."

Dr. W. Meyer expressed his opinion on the cracking of nickel on brass in three items: "I think it is a question of the magnitude of the stresses in comparison with the tensile strength of the base metal. If you put rather brittle nickel on lead it will crack easily, and if you put it on zinc you get cracking. The base metal must have strength. If you have a good adhesion it can inhibit the cracking."

STUDIES OF THE ACTION OF ORGANIC COMPOUNDS AT THE SURFACE DURING THE ELECTRODEPOSITION OF NICKEL

BY HENRY LEIDHEISER, JR., M.S., PH.D.

Virginia Institute for Scientific Research, Richmond, Virginia, U.S.A.

MR. JAMES CAPE offered some criticism of Dr. Leidheiser's theory of available pairs of electrons. Dealing with the examples given in the paper he said: "I agree with the first example, but I cannot agree with the second example. In R:C:N, the bond between the carbon and the nitrogen is a triple bond. He obtains a final ion by a series of reactions, first in which he breaks the triple bond to give the double bond and then a single bond; and he reacts finally on the amine with acid to produce an ion. I am not clear about his definition of available electrons.

"Some of the organic addition compounds which have been added to the nickel plating bath react with the constituents of this Watts-type bath. For example, the organic amines form key compounds with the nickel and hence increased the effective film of the nickel ion. Such compounds are formed with Pyridine and other similar organic amines, and also with some of the primary amines, including some of the large molecules which he gives. In addition, compounds such as aniline will react with boric acids to give salts. He has not made quite clear why some of these compounds cause small grain size in some of the deposits. He gives a list of organic compounds together with respective grain sizes. On looking down this list, I find that two nickel salts, benzaldehyde-m-sulphonate and benzene-disulphonate, give small grain sizes, as do several others, including Pyridine and Quinaldine ethiodide. All these compounds contain the meta-directing groups. The reason why the addition of these compounds results in small grain size is this: two English chemists have evolved an electronic theory based on a recently known theory that at metapositions one obtains a positive charge. Probably these compounds, owing to this positive charge, go towards the cathode, dragging with them some of the nickel ions. It is therefore difficult for the nickel to be deposited. It has to force its way through a layer on the cathode of these meta-directing and hence positively-charged types of organic molecules and, as it has to force its way through, only small quantities of nickel can get through at a time and the grain structure will appear to be small."

Commenting on Dr. Leidheiser's paper DR. FISCHER said: "In his adsorption experiments he has chosen to use copper and has compared adsorption on copper with the effects of the brightener in nickel deposits. It seems to me not practical to choose another metal for the copperising. He previously chose raney-nickel, and this seemed to be better. In the case of copper I must say that electrolytically-polished metals are covered with a film of oxide and if you do not remove this film from the surface you cannot obtain exact results concerning the adsorption. It is better to remove this film.

"As to the theory of the formation of brightness, we are in an interesting situation, for neither preferred orientation nor smallness of grain seems to be the origin. May I call attention to the known banding structures which are found in deposits. I recall an interesting paper by our Chairman

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and Mr. Phillips fifteen years ago on the banded structures in deposits. We have always found banded structures in bright nickel in cross-sections, and I would ask Dr. Leidheiser whether he, too, has studied the banded structure of the cross-section and whether he founded banded structures in his numerous experiments."

DR. HOARE, replying, agreed with with the comments on available pairs of electrons made by Mr. Kape and disagreed with Dr. Fischer, he said: "I do not think that aspect of Dr. Leidheiser's work is very helpful. I think he has to consider the adsorbability of molecules in terms of their shape, their deformability and dipole moment. In order to do that, we must not be too exact about the number of particular kinds of electrons there. We are more concerned with the more microscopic problem of the molecule as a whole.

"As to Mr. Kape's point about chelation by the amines, this does not arise because there is a lot of nickel and very little addition agent so that most of the nickel remains as aquo nickel ions. Another question was whether the small grain size was caused by addition agents. In certain cases it is; there is a tendency to prevent growth and you get small grain sizes. One can conceive of constituents where the adsorption equilibrium is so quick on the surface that although electrochemical reactions would be inhibited, at the same time there would not be great inhibition of crystal growth."

"I should like to mention hydrogen uptake and embrittlement of nickel deposits in the presence of sulphur. This is to some extent a parallel of hydrogen embrittlement being increased by the presence of sulphur in steel pickling. Sulphur seems in some way to stimulate hydrogen diffusion into steel and into nickel. It is therefore likely that the final addition agents which are used will not contain sulphur at all."

THE WEATHERING OF NICKEL/CHROMIUM ELECTRODEPOSITS

BY W. A. WESLEY AND B. B. KNAPP
Research Laboratory, The International Nickel Co. Inc., Bayonne, N.J., U.S.A.

OPENING the discussion, Dr. S. WERNICK in congratulating the authors on an outstanding paper commented on some of its depressing aspects from the plater's point of view. If the results of the paper were to be accepted, we had to accept the fact that nickel progressively increases in porosity as time goes on and that the process is accelerated by the superposition of a plating of chrome of the order of about 20 microinches. More alarming were the effects of some of the impurities in the nickel deposit. In bright nickel just a trace of sulphur or cobalt has such a deleterious effect and increases porosity. However, iron as a co-deposit had proved beneficial according to the paper.

He went on: "How does the pore in a nickel deposit or a nickel foil arise? This is a fundamental question. Why should it develop at a particular locality rather than anywhere else? There are a number of possibilities, and I will deal with three. It may be a local condition of potential porosity which is electrochemical in nature, or it may be due to local physical conditions such as the presence of scratches or microscratches. We were told yesterday that the presence of a scratch on a surface was likely to multiply the possibility of the production of a local pore, perhaps a thousandfold. That is a profound thought, because if a surface is produced mechanically, however polished it is, it is still nothing but a series of microscratches. To regard each as the site of a porous condition is a formidable thought. According to Dr. Evans yesterday, we need the base metal and the plating to be free from scratches. That is obviously impossible. I do not know how Dr. Wesley polished his stainless steel format, whether it was mechanically or electropolished. If it were mechanically polished, he must have had scratches and possible sites for an increase in local porosity.

"The third possibility is that we might have a near porous condition present which may be due to the fact that there are pores which are partly through the thickness of the film. They vary in thickness among them-

selves, and you expect the deeper pore to be first corroded."

E. A. Ollard said that deposits failed either by cracking within 24 hours of plating or, particularly in the case of bright nickel, by the lateral spread of pits under the chrome, possibly due, he thought, to the presence of layers of sulphide. This did not happen if the chromium deposit was perfect. T. P. Hoare commented on the uselessness of salt-spray tests required in many plating specifications.

Dr WESLEY pointed out the retention was not quite as discouraging as it might have seemed: "The troubles change their colour with the point of view. One cause of this feeling is that there has been some confusion of the behaviour of the foils with the behaviour which are to expect of coatings on steel. We know that if a foil will develop 10,000 pores a sq. in., then if a coating exactly like it is put on steel, the initial perforation will occur just as fast; but then there is no longer a further increase in the number, certainly in no way comparable to what happens to the three foils. The new factor which comes into play between the basis metal and the coating seems to prevent the further perforations of the coating in the coating in the area of the pore. Very many more pore cells develop in the foils in the later stages than one would expect with the plated steel which one observes in the same atmosphere."

BRIGHT NICKEL PLATING—A REVIEW OF PROGRESS

BY R. B. SALTONSTALL
The Udylite Corporation, Detroit, Mich., U.S.A.

MR. SALTONSTALL in reply to a question of Mr. Manning, thought it doubtful that the presence of sulphur in many bright nickel deposits might be the cause of the unseemly failure of these deposits. He thought Mr. Manning's idea of relieving bright nickel deposits by combining the drying out of plating work with stoving likely to cause serious difficulties. It would not give much relief and if the stoving was too hot or too long the physical properties might become unsatisfactory.

Referring to Mr. Miller's comments on difficulties caused by designers, he said: "I am horrified by some of the designs which we are expected to polish and plate these days. I had no intention of inviting designers to go still further in this direction when I made comments in the paper. The design of some articles, on which nickel cannot be deposited in sufficient thickness, does not help the situation at all. I was much impressed by a recent copy of one of your British Standards for nickel plating, for in the introduction there was a very polite caution to designers to the effect that if they wanted parts to stand up in service, they had better look to their designs. I wish we could get the designers in the United States to listen to something like that."

NICKEL PLATING FROM THE SULPHAMATE SOLUTION

BY MYRON B. DIGGIN, B.S., M.A., F.A.I.C.
Hanson-Van Winkle-Munning Co., Matawan, N.J., U.S.A.

MR. DIGGIN said in reply to questions raised by DR. A. E. DAVIES. The first question involved the differences between a sulphate solution and a sulphamate solution. We looked up the physical properties of Watts solution, the all-chloride solution and the chloride-sulphate mixtures, and we could not obtain the desired physical properties or maintain the ductility of deposits with any of those baths. We made some attempts with them and we made physical measurements with them, but we did not pursue the matter too far because there is a complete report in A.E.S. researches and the figures, which can be abstracted, are reliable. The sulphate solution would not produce the combination of physical properties which we had to have to meet the specification for this military application which I have described.

As to the effect of ageing, you will find it stated in the paper that the bath had been in operation for six

months, with air agitation, and that the deposits at the end of that time were the same in physical properties as when the solution was first made. This does not mean that the solution was made and then everyone walked away and forgot about it. It was kept in good physical condition. It was continuously filtered and about once every three or four weeks was given a treatment with activated carbon. The activated carbon does not remove the NTS, although a treatment with about 1 lb. per 100 gal. will remove between 25 and 30 per cent. of the NTS. You can remove it completely by preceding it with a hydrogen peroxide treatment and then using activated carbon, but we gave it activated carbon treatment to take care of incidental organisms which may get into the bath or breakdown products from the NTS. We are continually checking the physical properties, especially hardness, stress and ductility, and we have not found an appreciable difference during the six months of operation.

GLASS-FIBRE REINFORCED PLASTICS: A NEW MATERIAL OF CONSTRUCTION FOR THE FINISHING INDUSTRY

BY H. SILMAN, B.Sc., F.R.I.C., F.I.M., M.I.CHEM.E.
Ford Research Centre, Birmingham

POSSIBLE difficulties MR. CANN saw in the use of glass fibre for tank linings were the welding of the sheets, the heat transfer through the fibre and the effects of thermal shock.

As a supplier of tanks of this type, DR. W. R. MEYER found that their greatest trouble had been with small perforations. The tanks were mainly used for acid dipping. Because they were slightly hydrolised by strong alkalis they were rarely used for strongly alkaline resins. He advised against using them with a strong oxidising agent such as chromic acid.

His firm had tried to make polythene containers and felt that they were much more durable for withstanding nitric, hydrochloric and chromic acids.

The polyester reinforced glass fibre tanks were made in one piece and cured at one time, so no surface jointing problem arose. They were cured at slightly above room temperature because resins catalysed at room temperature might continue doing so. The materials were excellent for duct work. Polyvinyl materials were extensively used as piping for elbows, tees and for the piping around the plating room where there is corrosion on steel parts.

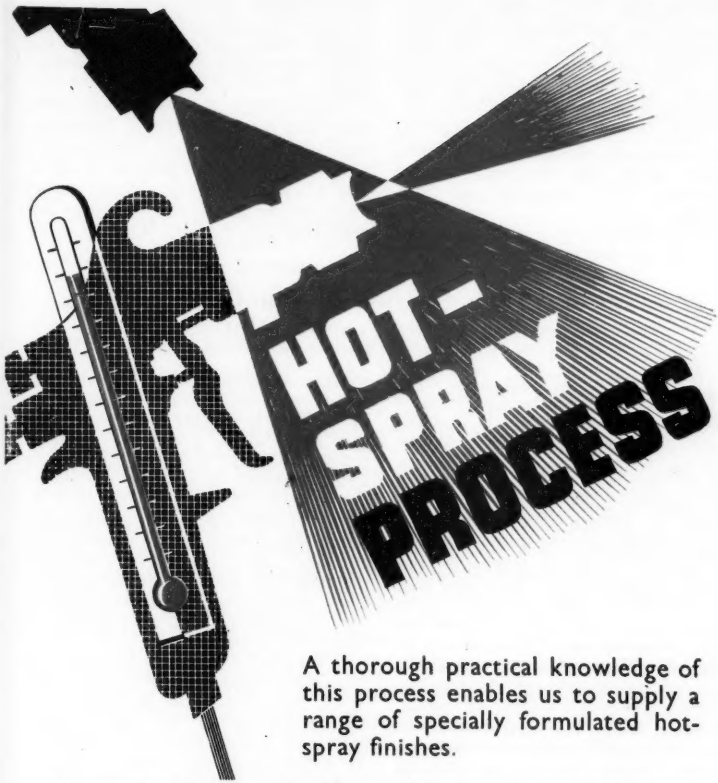
MR. P. QUINN spoke of his experience of these new materials. He said: "There are flexible versions of these resins which can be used. They are quite inert chemically, they eliminate troubles to do with differential expansion with metals and so on.

"I am surprised that he has not come out rather more strongly in favour of the woven glass reinforced materials, which have very definite advantages. Tubes with wall thicknesses as small as 50-thousandths can stand being thrown on the floor by the average man. I have never seen one broken in that manner yet, and I have tried it myself pretty hard.

"With regard to the coating resins which can be used in conjunction with metals for coating them, I wonder whether Mr. Silman has done any development along those lines. Perhaps the silicon surface coating materials which are now beginning to appear hold the greatest advantages of all. They are water repellent, and any electrolyte is repelled. Even if the materials are immersed they are not really wetted and, they can also display tremendous resistance to various chemicals.

"Some of the materials can be worked at temperatures as high as 130° C. I have tried putting solutions inside them at such temperatures. They can be used with oil heating systems."

MR. SILMAN replied: "The thermal transfer of the solution in these materials is extremely bad. I have no figures for this, but you save fuel in that you do not have to heat inside and out. Resistance to thermal shock is very good. Jointing can be made by using the actual resin itself. You get excellent joints because the resin is directly suitable for bonding with itself. There is no need to make any joints whatever. It is possible to lay out the sheet dipped in the liquid resin



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and produce a completely homogeneous tank by methods other than fabrication from sheet. In some ways the sheet fabrication technique is simpler, and it gives flexibility, but there is no need to employ it.

Methods of jointing, repair or attachment are simple. You make a dough which you can apply almost anywhere, thus plugging up little defects.

Rods and bars can be produced, and they can be machined, although it is not usually necessary to do that because the materials can be wound round a mandrel or block and can easily be withdrawn because they shrink.

"The temperatures which the polyester resins will resist is extremely high because they are not thermoplastic. Curing is carried out at up to 160° C., which gives an indication that the temperatures for continuous operation can be very high."

THE ELECTRODEPOSITION OF POROUS METAL

BY CHARLES L. FAUST, PH.D., AND WILLIAM H. SAFRANEK
Battelle Memorial Institute, Columbus, Ohio, U.S.A.

DR. C. L. FAUST said in his reply to questions that the suggestion of MR. R. A. F. HAMMOND that the porosity resulted from metal deposition around gas bubbles was feasible, but so far there was no proof that that was the cause.

MR. H. SILMAN as well as MR. HAMMOND referred to the fact that the porosity increased at low *p*H and at high temperature. This was true for the nickel deposits and for the copper, but it was just the reverse for zinc. He went on: "The thought of electro-forming intricate shapes with porous metal is very intriguing to us. We have not tried it with these porous materials, but I feel quite optimistic about being able to electro-form complicated shapes because the throwing power is very good. Unfortunately the ends of the cylinders illustrated had been cut off for other tests, and so we could not see the very excellent throwing power at the edge. The edges were not built up very much in thickness as they would be in the normal solid plating process.

"DR. ZENTLER-GORDON raised questions of adhesion, hardness and brittleness. The adhesion in such tests as we have made has been very good. In the case of copper on a steel back it was sufficiently strong to exceed the strength of the coarse fibres. With such small cross-sections in the fibres the apparent strength of the porous materials is low. The attachment to the basis metal is greater than that strength.

"As electrodeposited, these porous metals were relatively brittle. The copper could not stand much stressing without cracking. The nickel plate could stand considerably more stressing. There is a figure in the text of a little over 500 lb. per sq. in. of stress before fracture. It has a rather high tensile strength in view of the size of the crystals.

"Mr. Ollard asked whether the dispersal agent itself had any effect on porosity. We have tried different materials but we have been unable to learn whether they were comparable with the others. The ones which we used gave us no porosity.

"There is no reason to feel that the protective colloid in the case referred to on the last page of the paper had any responsibility for the results, although I think that it did indirectly by assisting the graphite to remain longer in suspension.

"DR. BLUM asked what was in the holes. We did not find anything except perhaps a small amount of the occluded graphite in some of the blind holes. The rinsing appears to have removed whatever might have been in those which were interconnected and through which water could flow.

"MR. SILMAN asked about machining or reaming the material, without closing the pores. This is an important question. It is a difficult accomplishment to perform machining without some closure of the pores. When we prepared bearings for testing we encountered that trouble. We reopened the holes in the case of such closures as were caused by the machining by means of a mild reverse current treatment in the plating solution. As nearly as we could tell under the optical microscope, we had sub-

stantially restored the pore structure that we originally had.

"DR. HOCH asked about the inclusion or occlusion of abrasives. That is a very interesting application for this type of material. There are procedures by which diamonds in particular and other abrasives can be cemented in place by having electrodeposited metal around them. There are diamond grinding and finishing wheels produced in that manner now. I am optimistic about enclosing such abrasives with this porous material by substituting the porous deposited solution for the other kind in a similar operation."

UNIVERSAL METAL FINISHING PROBLEMS—A PLEA FOR INTERNATIONAL CO-OPERATION

BY S. WERNICK, PH.D., M.SC., F.R.I.C., F.I.M.
Consultant, 17 Alexandra Grove, London, N.12

AND

UNSOLVED PROBLEMS IN THE METAL FINISHING INDUSTRY

BY W. L. PINNER
Houdaille-Hershey Corporation, Detroit, Mich., U.S.A.

MR. J. F. KAYSER suggested that research associations—such as the British Non-Ferrous Metals Research Association—should obtain all proprietary articles, analyse them and publish the results to aid commercial establishments to choose what they need more easily and to avoid time wastage.

DR. K. G. SODERBERG defended the supply houses. He maintained that much of the progress in the industry came from the supply houses. Such service came from the profits from sale of products. As soon as they divulged exactly what they were doing, people would try to get the same goods cheaper elsewhere and these services would break down.

DR. W. BLUM supported Dr. Wernick's plea for further and more effective international co-operation in knowledge sharing. He believed the International Council might well extend its scope and hold annual meetings alternating between the United Kingdom and the United States.

He referred to the present difficulty of the American Electroplaters Society Research Committee in getting qualified men for their projects, saying, because of this the Battelle Institute was conducting work in Europe, making use of the scientific ability of the Europeans. He thought that a meeting could probably be arranged with the Research Committee to discuss projects under consideration and those which could or could not be undertaken.

DR. A. W. WALLBANK called for a fight for a far higher status in industry for the plater and gave the instance of his combine where finishing costs were a quarter of the total costs but neither the number of technicians nor their salaries followed the same proportions.

In his reply DR. WERNICK proposed the motion:

> "That the International Council for Electrodeposition be asked, in the light of the proposals made by Dr. Blum and Mr. Hull, to explore the possibility of universal co-ordination in research projects on metal finishing, and in the first place to implement a programme between the Institute of Metal Finishing and the American Electroplaters Society." It was passed unanimously.

Symposium on Celluloses.—A symposium on "Recent Advances in the Chemistry and Industrial Applications of Cellulose" will be held by the Royal Institute of Chemistry at the University of St. Andrews, 28th June, to 2nd July, 1954. Professor J. Read, F.R.S., will open the symposium and three sessions for the reading of scientific papers will be held in the Chemistry Department Lecture Theatre.

Change of Address.—The address of British Industrial Solvents Ltd. has now been changed to Devonshire House, Mayfair Place, London, W.1. Telephone Mayfair 8867.

The Dalic Plating Process

Apart from the introduction of the barrel and the development of a wide range of plating solutions, there have been few major changes in the technique of the plating process in the last fifty or sixty years. A new process, introduced from France last year, may truly claim to offer revolutionary advantages for certain specialised classes of work and its use and principles are discussed in this article.

FOR many years there has been a demand for a simple method of electrodeposition which can be applied to work on the bench and *in situ* on machines or assembled equipment. Typical examples are the building up of worn hydraulic rams, undercarriage legs on aircraft, propeller blades of of aircraft and ships, electrical contact surfaces, waveguides or protective coatings on parts only of long objects such as rods or tubes which are too large for the conventional plating vat.

The treatment of these parts by orthodox methods is often impossible or extremely costly and has frequently involved extensive dismantling or stripping down. The Dalic process, which has been the subject of considerable interest in the engineering and metal working industries over the last year, or so, is, in effect, a method of overcoming these disadvantages and may almost be described as "plating brushed on."

Lest this over-simplification should mislead the reader we would hasten to add that there is nothing "chancy" or doubtful about the method; it is an extremely practical and economical proposition.

Briefly the system consists of the use of a control cabinet or power unit which incorporates a transformer, rectifier and the necessary voltmeters, ammeters and controls together with safety devices.

Plugged into the A.C. mains, this unit provides D.C. power for plating processes at a reduced voltage range of = to 26 volts and a maximum amperage of 40. The component to be worked on is made the cathode by connecting it to the negative terminal of the unit, via a crocodile clip and a flexible lead.

The anode or positive lead terminates in a plug or connector to which are attached various "tampons." These consist of an insulated handle, into which is plugged the anode lead and, at the other end, a carbon electrode.

In order to dissipate the heat generated during plating, the tampons are provided with cooling fins on the medium sized range, water cooled jackets on the really large ones and mere insulated handles on the very small ones. The large water cooled instruments have hollow electrodes and provision is made for circulating water round the tool. A roller electrode is also used for heavy continuous areas of deposition.

Provision is made in most of the tampons for a pad of cotton wool or glass fibre material which is the medium in actual contact with the work. The pads are so located and arranged that they lie clear of the bench or table when the tool is laid down.

Plating is effected by brushing the electrolyte on the workpiece with the pad of the tampon and plating can thus be carried out with extreme accuracy on selected areas of the workpiece. A list of the metals which can be deposited by the process is given in the accompanying table.

Organic compounds of the metal to be deposited are supplied as electrolytes. These fluids are supplied in small bottles ready for use and it must be pointed out that, as the process is designed to be operated in literally any odd corner or wherever the work happens to be, the use of conventional chloride and cyanide solutions is not possible, nor can fume removal be conveniently arranged so the electrolytes have to be specially designed with this in mind.

Both the tools and the electrolytes are protected by patents and are a little more expensive than conventional solutions but this is no drawback as the quantities used are quite small and there is practically no wastage.

The fluids available include, in addition to every possible class of plating electrolyte, a wide range of cleaners, stripping solutions and special fluids for chromium, cobalt, iron, nickel and chromium nickel coatings. None of the solutions are poisonous and none have any detrimental effect on the human skin.

The procedure is as follows:

The appropriate tampon, after being dipped in the electrolyte, is applied lightly to the workpiece with a rubbing motion. A separate tool is used for each solution and, with practice, an even deposit of considerable accuracy can be built up. The deposits have high adhesion and, usually, low porosity. This is considered to be due to the rubbing action which releases trapped hydrogen bubbles and ensures a high standard of corrosion resistance.

The average rates of deposition with the Dalic solutions are rather higher than the more conventional electrolytes, therefore, owing to the high current density employed, there would be a risk of arcing and burning if the electrodes came into accidental contact with the work through wear of the pad or careless manipulation. This is taken care of by the provision of an instant overload cut-out which comes into operation in such circumstances. This avoids accidental damage to the work or the tool.

The rates of deposition given in the Table may, at first sight, appear high but it must be remembered that they are applied only to the small area on which the tampon pad is in contact, therefore, they must be considered in relation to the total area to be plated. Maximum thicknesses compare favourable with any of the conventional processes and in some cases even better thicknesses can be obtained.

Preparation for plating follows

SOME CHARACTERISTICS OF DALIC ELECTROLYTES

Type of Solution	*Metal Concentration gm. per litre*	*Maximum Current Density (amps./sq. ft.)*	*Rate of Deposition (sec. per 0·001 in. thickness)*
Bismuth	100	1,500	75
Cadmium (acid)	150	6,000	25
Cadmium (alkaline)	80	6,000	25
Chromium (No. 1 alkaline)	80	4,000	625
Cobalt	30	1,500	75
Copper (acid)	70	6,000	25
Copper (alkaline)	60	6,000	25
Copper (spec. pure)	70	6,000	25
Gallium	—	1,000	175
Gold	100	2,000	75
Indium	70	4,000	25
Iron (pure)	25-30	3,000	100
Lead	100	5,000	25-50
Nickel (No. 1 acid)	70	5,000	50
Nickel (No. 2 acid)	100	5,000	50
Nickel (alkaline)	30	5,000	50
Nickel (black)	20	5,000	50
Palladium	—	1.500	100
Platinum	50	3,000	175
Rhodium	20	3,000	1,000
Silver	300	1,250	50
Thallium	—	2,000	100
Tin (acid)	70	5,000	25
Tin (alkaline)	70	5,000	25
Zinc	100	3,000	25-50

closely on accepted practice. For example, acid copper on steel is preceded by electrolytic cleaning and an alkaline copper "strike" coat. The cleaning solutions will tackle most of the normal dirt and slight rust, tarnish, etc., but, if heavier deposits are to be removed some degree of abrasive cleaning is necessary.

The equipment is not particularly expensive, a minimum outfit costing in the region of £260 to £300 and more elaborate equipment in proportion. It has found wide acceptance in the workshops of several of the larger airline services including Air France and other Continental lines and is being adopted on an increasing scale by many engineering firms for salvage and rebuilding of worn parts.

Other proved applications include; plating direct on aluminium, anti-fret coatings, stopping-off for carburising, X-ray anti-cathodes, bearing surfaces, brazing without flux, correction of machining errors, etc.

The Dalic process is operated and licensed in this country by Metachemical Processes Ltd., 13 Stratford Road, London, W.3. The sponsoring firm have a demonstration plant available and are willing to discuss possible applications with interested parties.

SYNTHETIC RESIN PROTECTIVE COATINGS

IN the present difficult conditions under which the country is labouring, it is becoming more necessary than ever to employ efficient methods of protecting plant and machinery against corrosion especially in the plating and kindred industries, the plant of which is particularly subject to corrosive elements.

Interesting, therefore, in this connection is the work of Detel Products Ltd., of South Ruislip, Middlesex, who are the pioneers of chlorinated rubber coatings as a medium of protection for almost every type of surface.

Their Detel coatings consist of chlorinated rubber and other synthetic resins of a similar character dissolved in a mixture of high flash (100° F.) aromatic hydrocarbons in which is ground a suitable pigment. These paints dry by evaporation and not by oxidisation so that drying is more rapid that that of oil or even of synthetic paints and resembles that of lacquers. Most pigments can be ground in Detel medium as it is very inert and will protect sensitive pigments from the action of acids or alkalis. The best protective compositions, however, are made with highly resistant pigments such as Titanium dioxide.

The coatings are unaffected by cold and will withstand dry temperatures up to 230° F. They can be divided into two main groups, the first protects by reason of its impermeability and general resistance to corrosive agents and the second because of its chemical composition.

The first is used mainly on plaster, wood, metal or cement and is completely resistant to chemical attack. In plating shops, it is used to protect walls, ceilings, floors and benches and all cement work used in storage and pickling tanks and also in construction of acid and alkali-proof tanks and similar equipment.

Where the surface needing protection is either iron or steel, the second type is used. This is known as D.M.U. (Detel Metal Undercoat) and requires top coats for finishing off. This undercoat depends mainly on its high metallic zinc content (over 96 per cent.) for its protection of these materials.

D.M.U. was first extensively used as a marine anticorrosive in 1936 and its use greatly increased during the war. It is equally efficient in the general industrial field and is successfully protecting plant in factories, sewage, water and chemical works and plating and descaling shops.

It is interesting to note that the plating industry in particular is now making extensive use of Detel for coating jigs and for stopping off or masking in the Chromium Plating bath, a very fine example of its uses as a corrosive resisting agent. It might be mentioned that Detel is extremely simple to apply and economical in use and there is no danger to the operator whatsoever.

Nu-Swift Ltd.—Nu-Swift Ltd., well known for its fire extinguishing equipment, has just received its first order for pressure-charge-operated Nu-Swift extinguishers from the Royal Danish Navy. The Danish Navy is the fifteenth navy to install Nu-Swift equipment.

Evode Expansion.—As part of their current programme of expansion, Evode Ltd., makers of water-proofing and protective compounds, adhesives and paints, have established new offices at 1 Victoria Street, London, S.W.1. Considerable development is also in hand at the Evode factory and laboratories at Stafford. Production capacity is being extended with the erection of a new set of buildings. The new London offices, initially designed to ease the head office of increasing admimistrative pressure, are to be further extended at a later date to accommodate growing export business.

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American Finishing Developments

A DIGEST OF THE ARTICLES DEALING WITH FINISHING PROCESSES, WHICH HAVE BEEN PUBLISHED IN U.S.A. TECHNICAL JOURNALS.

Simple Fixture for Plating Tank Automatically Controls Solution Level.—A simple fixture may be made and hung over the top edge of any plating tank to automatically maintain a constant solution level. Paul E. Miller, Miller Electroplating Inc., Evansville, Indiana, designed such a device, shown on the accompanying ilustration.

At the top of the fixture is an ordinary iron pipe tee (A) resting at the tank edge. This tee is ¾ in. or 1 in. pipe size. Screwed into this tee is a short piece of pipe (B) with a hose (C) attached to it to prevent electrical grounds. To the bottom of this tee is fastened a pipe (D) projecting down into the solution. Ordinary black iron pipe can be used in any cyanide bath or electrocleaner. For a nickel or chromium solution, lead pipe should be used—a piece of heavy-duty lead pipe which can be fastened into the tee with the aid of a nipple (E) soldered into the pipe, and the nipple screwed into the tee. Into the top of this tee the make-up water can be dropped (F), or permitted to flow into this opening.

The top of this tee should be left open, the water being permitted to drop into it. If a tight connection is made at this point, a siphoning action starts, drawing the solution out of the tank and into the sewer, or on to the floor.

The effectiveness of this device is in the length of the pipe (D) protruding down into the plating solution. Solutions 30 in. deep or more work best. The longer the pipe is, the lower the solution level will be—the best length being determined by trial and error. A good method is to set the apparatus into a plating tank with pipe (D) going down near the bottom and then, as the solution level is raised, remove the apparatus and take off one or two inches of the pipe at the bottom. This will lessen the weight of the column of pure water and as this weight is reduced, the plating bath will rise until the desired solution level is found. The surplus water being fed in at (F) will then pass out the overflow (B); and the device therefore becomes automatic.

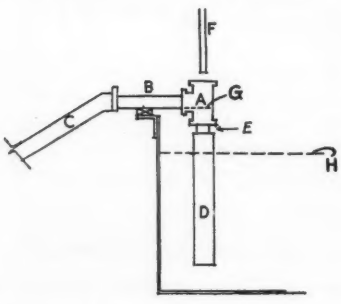


Diagram of device. F make-up water, G pure water level and H solution level

A valuable source of clean water for the device may be had from the condensation from steam heating coils. When introduced into a plating bath this will have no effect upon the acidity of the bath. Pure water from the heating coils is especially useful in localities where the source of water contains many undesirable minerals.

The only manner in which this level control might cause a solution to overflow would be the development of a leak somewhere between the tee (A) and the bottom of the feeder pipe (E and D). A leaking heating coil will also cause an overflow.

In case new anodes or chemicals are added to the bath which might have a tendency to raise the level of the solution, the device will prevent any additional water being added until the bath level has again gone down to the predetermined level.

This solution leveller is now in use in most of this company's plating and cleaning tanks. In the case of cleaning solutions of very light density, such as those used for cleaning zinc die castings, it is necessary that the pipe (D) extends to just about the bottom of the solution; otherwise the solution level will be too high.

Overflow from the hose (C) may be put to work in a swill tank, level automatically maintained to save a considerable amount of metal salts and plating solution. One chrome tank

indicated a saving of 50 per cent. in chromic acid by use of overflow from the hose.

(*Products Finishing*, September, 1953.)

Cold Galvanizing with Metallic Zinc Paints Protects Exposed Metal Surfaces and Welds from Atmospheric Corrosion.—Steel and iron surfaces exposed to corrosive atmospheres can be "cold galvanized" with paints that contain 93 to 95 per cent. metallic zinc to assure protection, according to Sealube Company, Wakefield, Massachusetts, makers of a zinc-rich paint, ZRC. This company reports that the electrochemical protection afforded in this manner is comparable to that of other zinc coatings, including hot-dip galvanizing, electroplating or tumbling.

The paint can either be brushed or sprayed on (Sealtube recommends brushing) such things as structural steelwork, bridges, metal window frames, steel staircases, corrugated iron roofing, gutters and downpipes, water tanks, railway installations, gas storage tanks, ships, dock and harbour installations.

Theory. When corrosive conditions exist on a steel or iron surface, electrochemical cells are set up between cathodic and anodic areas. Corrosion takes place at anodes, where metal passes into solution in the electrolyte.

Zinc is anodic. When it is placed in electrical contact with a steel surface, the whole steel object becomes cathodic. Corrosion then is able to attack the zinc coating.

In the early stages of corrosion, protective action depends upon zinc sacrificing itself for the other metal, but this does not continue indefinitely. Cathodic action also deposits a protective calcium carbonate or zinc hydroxide film.

Coating. Uncoated surfaces exposed by abrasion or faulty application, will rust, but sideways corrosion, as in the case of normal paint finishes, does not occur. Corrosion is absorbed and arrested by the zinc film.

The ability to stop corrosion means that zinc-rich paint can be applied over such surface conditions as adherent rust and mill scale. Absolutely clean surfaces are not necessary to insure satisfactory adhesion. In fact, rusty surfaces make a direct electric contact, and the spread of existing rust is arrested. However, surfaces should be dry and free from grease. Loose rust scale and paint should be removed by a wire brush.

Because of their conductive properties, zinc coatings also are used as welding primers. After welding, parts of the completed structure difficult to reach by normal painting are protected, as well as the welds themselves.

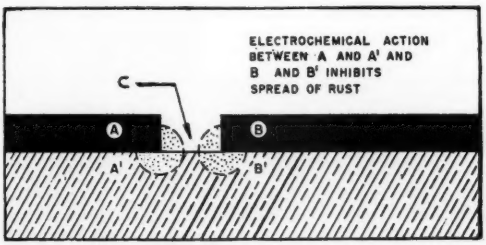
A zinc paint coat of ¼ oz. per square foot is prescribed for metal priming. When used alone as a protective and finishing coat, it should be applied 1 oz. per square foot. Coats are dry to the touch after 30 minutes and firm and hard in approximately 4 hours.

The paint has a light grey, flat finish, which can be used without further decorative treatment. It also serves as a base for oil-bound or synthetic paints and low-temperature baking finishes. The effectiveness of the paint is wholly dependent upon the high proportion of metallic zinc. Paints containing 95 per cent. or more of the metal, for instance, have about twenty times the electrical conducting properties of an 86 per cent. zinc paint product.

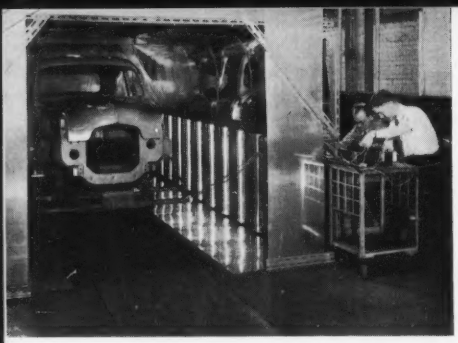
Anti-fouling treatments and compounds can be applied over zinc paint, but it should not be applied over tar or bituminous paints, or vice versa.

(*Steel*, September, 1953.)

Pyrometer Catalogue.—We have received a copy of the latest Thermo-electric Pyrometer Catalogue, No. 112 of Foster Instrument Co. Ltd., Letchworth. This issue supercedes Catalogue 103 and all previous issues. Because the firm make a great deal of temperature control and measuring instruments for special applications which are too numerous to include within the scope of a catalogue, they include a questionnaire form showing the information they require to enable them to give a quotation.



Drawing shows protective action of zinc coating where the ferrous surface is exposed. Key: A and B. Zinc coating A and B Iron or steel. C Scratch or abrasion



Left: Metrovick pilot plant for two-tone stoving Ford Zodiac bodies

TWO-TONE STOVING ON FORD BODIES USING INFRA-RED ELEMENT PROJECTORS

TWO-TONE stoving of synthetic paint on motor-car bodies has been, in the past, a difficult problem for car manufacturers because of the need to avoid discoloration of the lighter colour on the top half of the body.

Brigg's Motor Bodies Ltd., Dagenham, who are members of the Ford Group, have now successfully overcome this difficulty for stoving the lower section of the new Ford luxury car, the Zodiac, by using electric infra-red projectors.

The finish used on all Ford cars is a very durable synthetic enamel requiring a high stoving temperature of the order of 300° F. Attempts at ordinary convection stoving had resulted in the paint on the top half, already stoved, being heated again, and becoming discoloured. It was therefore decided to investigate the possibilities of localised radiant heat and Metropolitan-Vickers Electrical Co. Ltd. built a pilot plant at their Trafford Park Works, Manchester, large enough to accommodate a complete Zodiac body on its trolley. All Ford/Briggs colours were tested, including Winchester Blue, Channel Green, Dorchester Grey, Bristol Fawn and Opal. This was essential as stoving times are sometimes affected by the colour and some colours tend to have variations in shade if unevenly stoved.

Tests were entirely satisfactory and the pilot plant developed in conjunction with the engineers from Brigg's Motor Bodies Ltd., formed the basis for the oven and heating arrangements in the production plant installed in a new paint shop specially constructed to deal with this stoving on the Zodiac body.

The plant is "L" shaped in plan, and consists of a spray booth, flash-off section, stoving section and 6 ft. vestibules at each end. The overall length is 200 ft., with the actual radiant heating section occupying 120 ft. Stoving time for each body is 15 minutes.

The total installed load of the oven is 664 kW., which is adjustable by means of energy regulators and contactors to a normal operating load of 400 kW. As a safety measure, the conveyor is interlocked with the banks of element projectors so that if the conveyor stops, then the radiant heat is automatically switched off.

B. H. Chemicals Ltd. have announced that they have concluded manufacturing and selling arrangements with **Industrial Services Ltd.**, 118 Grafton Street, Dublin, Eire, whereby they will be manufacturing a wide range of Collex products under licence for sale in Eire.

Industrial Services Ltd., Dublin, is under the direct control of W. E. Calcutt, Esq., who will be able to give Irish customers full service backed by the B. H. Chemicals London Laboratories.

Right: Our illustration shows the arrangement of the infra-red element projectors in the stoving oven on the production line

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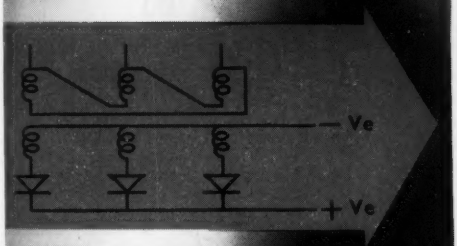

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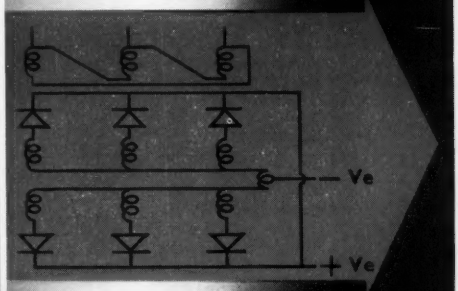

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British Iron and Steel Research Association Annual Report

—Finishing Aspects

THE British Iron and Steel Research Association has recently published its Annual Report for 1953. Contained in it are sections of interest to the finishing industry which we print below:

COATINGS COMMITTEE, MECHANICAL WORKING DIVISION

Acid Recovery

A considerable amount of free acid exists in waste pickle liquor solutions and it is important that such acid should be recovered. As a result of work in the Swansea Laboratories, a new evaporating method has been investigated which is thought to operate more economically and produce larger crystals of ferrous sulphate monohydrate than those used at present. The monohydrate crystals which result from the evaporation of waste pickle liquors are filtered off and the remaining sulphuric acid and water are returned to the pickling lines.

Autoxidation Pilot Plant

The erection of the pilot plant for recovering sulphuric acid from the ferrous sulphate contained in waste pickle liquor is now nearly complete and it is expected that preliminary trials will soon take place.

The Electrochemical Behaviour of Tinplate when used as a Food Container

The two most important factors which affect tinplate behaviour when used as a food container are the type of food and the presence of uncoated areas of steel in the tinplate. A radioactive technique has been devised in collaboration with the Atomic Energy Research Establishment at Harwell by means of which any untinned areas are easily detected and an actual estimate of these areas may easily be obtained.

Certain types of food tend to dissolve tin from the inside of the can without evolving hydrogen—a phenomenon attributed to the presence of one or more depolarizing agents in the food. As oxygen is itself a depolariser, tests with various fruit juices have been carried out in the absence of air in an effort to isolate and examine the actual depolarisers. Experiments so far show that of the fruit juices examined, raspberries dissolve tin more readily and yellow plums less readily than Victoria plums and it may be the red colouring matter —perhaps an anthrocynin dye—which contains the depolariser.

Electrodeposition of Iron-Zinc Alloys

Electrodeposited iron-zinc alloys developed by the Association have aroused much interest during the year and further tests have been carried out in order to improve and to study their properties and plating methods. Suitable additions to the plating bath have made it possible to deposit the corrosion resistant, higher zinc alloys in a lustrous form, and it is hoped that these alloys, which do not fingermark easily, will be useful replacements for electrodeposited zinc and cadmium, and perhaps even for nickel as an undercoating for chromium.

Hot Dip Aluminising

During the year, further work has been carried out on the hot dip coating of steel with pure aluminium and various aluminium-silicon alloys, and their properties have been investigated. Of particular note has been the heat resistance of aluminised articles at all temperatures up to 700° C.; considerable protection to the steel base was afforded even when aluminised articles were heated to this temperature for more than 2,000 hours.

Passing the strip through a glycerol bath to prevent oxidation before it enters the molten aluminium has been successfully used to do away with the need for controlled atmospheres and prefluxing; a similar technique is about to be tested in continuous galvanizing and tinning.

Extraction of Zinc from Galvanizers' Dross

During the hot dip galvanizing process, the molten zinc dissolves a good deal of iron from the articles being galvanized, the bath itself and other sources, such as pickling salts, and forms an iron-zinc alloy.

A process has now been devised and patented for the recovery of nearly 90 per cent. of the zinc contained in galvanizers' dross. This process is

simple and cheap to operate, although as with any other recovery process, particular attention must be paid to the current relative prices of zinc and galvanizers' dross. The method makes use of the fact that aluminium has a greater affinity for iron than has zinc and that zinc is very soluble in molten lead, but much less soluble at lower temperatures.

In the recovery process, the dross is added, with the correct amount of aluminium, to a molten lead bath. Zinc is liberated and dissolves in the lead, while the iron and aluminium combine to form a light alloy which is skimmed off. The lead is then allowed to cool, whereupon most of the dissolved zinc crystallises out and may be separated.

Tests are now being carried out on possible improvements of the process; for example, an aluminium-silicon alloy increases the amount of zinc recovered.

CORROSION SECTION, CHEMISTRY DEPARTMENT

The transfer of the Corrosion Section to its permanent quarters at Battersea was completed in October.

As a result of a conference between members of the Corrosion Committee, its Sub-Committee and Study Groups, it became clear that the results of the work of the Section and the implications thereof in respect of the most suitable means of combating corrosion of iron and steel were not being as widely applied in practice as is desirable. It was suspected that the reports issued by the Association or published in scientific and technical journals were not reaching those whose concern it is to prevent corrosion. Because of this, a panel has been formed to study and advise on means whereby wider application may be secured. As a first step, advice has been sought from the various professional engineering institutions. Wider publicity has also been given to the work of the Section by the writing of an article in the *Times Science Review* entitled the "Corrosion of Iron and Steel and its Prevention" and by a broadcast talk entitled "The Fight Against Rust."

A research into the corrosion resistance of low-alloy steels has been completed and a report is to be published early in 1954 in the *Journal of the Iron and Steel Institute*. The principal conclusion is that under conditions of atmospheric exposure the corrosion rate of steels containing small percentage additions of chromium, copper and nickel is not more than one-third of that of ordinary mild steel. When immersed in sea water, small additions of alloying elements are not so beneficial; the corrosion rate is halved by the addition of 3 per cent. chromium and there are indications that aluminium and beryllium additions may be of value. Differences in carbon content had little effect on the measured corrosion rate and there was a negligible effect due to heat-treatment. Cast iron corroded less rapidly than unalloyed low-carbon steel in the atmosphere but at about the same rate when immersed in sea water. Some graphitisation occurred in cast iron under the latter condition. It proved impossible to correlate the results of accelerated laboratory tests with those of outdoor exposures.

Tests in the B.I.S.R.A. rotor apparatus on nodular cast iron have shown that, in both distilled water and sea water, some specimens are liable to severe graphitisation and erosion. Further specimens, together with samples of pipes protected with bitumens and tars —both hot-dipped and sprayed—have been buried at three sites; they will be removed in due course.

All the specimens in a research on the protective value of priming paints have been removed from the Derby exposure site after seven years' exposure and a report on them will be prepared shortly.

A new Joint Technical Panel (J/P4) has been formed in collaboration with the paint industry to study the protective properties of various paints applied to metallic coatings on structural and light-gauge steel when exposed to the atmosphere, water and soil.

Sets of specimens, which have been exposed inside factories and dwelling-houses for one year, have been examined. The corrosivities of the sites chosen varied widely and the results have shown that coatings of sprayed zinc were superior to those of sprayed aluminium but that low-alloy steels were not more resistant to corrosion than mild steel. Some of the specimens remain exposed and will be examined later.

Tests have been completed to find a suitable maintenance anti-corrosive composition for application to ships' bottoms when in dry dock. Specimens were given a first coat of paint, currently in use for new construction and allowed to dry thoroughly before receiving an anti-fouling coat; they were then immersed in the sea. The tests continued for two years, the specimens being removed at six-monthly intervals, brushed down and coated with one of four experimental paints, suitably formulated for application in dry dock, and re-immersed after brief drying. All the maintenance paints proved suitable, but one was much better than the others. Service trials are now envisaged on ocean-going vessels. The surface preparation before painting was found to have a marked effect on the behaviour of all the painting schemes. Those specimens which

were pickled to remove all mill scale, weathered for 2¾ years and wire brushed before painting were superior to those which had been pickled and weathered for a short period or to those which had retained various amounts of mill scale after weathering for short periods.

Tests are being undertaken to determine the resistance to corrosion of hot-dipped aluminium and of electrodeposited manganese coatings on steel. The specimens were prepared at Sketty Hall and the Fulmer Research Institute, respectively.

A research has been commenced which is intended primarily to compare the accuracies of available coating thickness meters when used for sprayed coatings of non-ferrous metals on steel. It is hoped to develop a more reliable thickness tester for use on curved surfaces and a prototype is being designed.

Microanalytical methods have been devised for determining the weight of phosphate coatings on small areas of steel and producibility tests are being conducted at a number of laboratories.

Fundamental research work has continued at Cambridge University.

It has been found that the true inhibitors present in red lead oil paints are not the soaps contained in them but salts of dibasic acids and other degradation products of these soaps.

A seasonal character of rust—which becomes favourable for paint application in the summer months but unfavourable in the winter—has been detected. The possibility that this behaviour is due to varying amounts of electrolyte in the rust is to be examined.

Although the combined action of calcium compounds and condensed phosphates inhibits the corrosion of steel in water containing chlorides, their protective action is not long lasting. This appears to be due to a breaking down of the protective film formed initially.

Experiments have been carried out to decide whether the special resistance of wrought iron could be attributed to the formation of phosphate film during exposure to air. Electron diffraction studies of films stripped from polished specimens do not support the view that wrought iron is a "self-phosphating" material. The behaviour of wrought iron towards corrosion may be attributed to its lamellar structure which in general consists of quickly corroding, relatively resistant and very resistant zones. The degree of attack in any environment will depend upon the orientation of these zones to the surface. A sample of lap-welded wrought iron tube from a marine boiler, which had given twenty-five years' satisfactory life, was found to have continuous very resistant zones on both the outside and inside faces.

THE PRODUCTION EXHIBITION, 1954

BRITAIN'S first Production Exhibition, Patron, H.R.H. the Duke of Edinburgh, which is to be held in the National Hall, Olympia, from 7th to 14th July, 1954, has for its theme "Production for Plenty." This theme will be introduced by the British Productivity Council's exhibit explaining the meaning of productivity and the importance of increased production to the welfare of the community.

On one side of the National Hall, devoted to methods and processes, there will be displays of industrial finishing, production engineering research, precision casting, instrumentation and other processes contributory to improved productivity. On the other side supplementary services will be prominent—such as X-ray examination of metals, scientific instruments, developments related to basic materials and metals and aids to production such as lighting and colour in the factory.

The central avenue of the Exhibition is devoted to Research Development, and will contain an exhibit from the Department of Scientific and Industrial Research and the British Standards Institution. There will be sections on training and vocational guidance.

Next to the central avenue will come organisations showing planning and production methods.

The Production Conference

At the conference running concurrently with the exhibition, amongst other papers, those likely to be of special interest to finishing firms are: "Standardisation in the Process Industries," E. W. Greensmith, A.C.G.I., B.Sc., M.I.Mech.E., Engineering Services Department, Imperial Chemical Industries Ltd., Session VII, 12th July, 3 p.m.; and "Introduction of Work Study into Smaller Firms," H. G. Wood, M.A., B.Sc., M.I.W.M., Chief Work Study Officer, British Productivity Council, Session VIII, 13th July, 11 a.m.

Change of Address.—The new address of the Institution of Production Engineers is 10 Chesterfield Street, London, W.1. Telephone Grosvenor 5254/9.

Exporting to Canada.—For those exporters interested in the Canadian market, a revised edition of *Exporting to Canada*, was published by H.M. Stationery Office, on 4th May, price 3s., by post 3s. 3½d. This booklet, which follows the same lines as the edition published in 1951, has been brought up to date and extensively re-written.

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Names in the News

DR. J. W. CUTHBERTSON

Professor of Metallurgy, Nottingham University

DR. J. W. CUTHBERTSON, at present Assistant Director of Research at the International Tin Research Institute, Perivale, Greenford, Middlesex, has been appointed Professor of Metallurgy in a new department created by the University of Nottingham.

All his friends in the finishing industry will acknowledge the very fine work he has done on behalf of tin and tin alloys in recent years, and all members of the Institute of Metal Finishing will doubtlessly wish him the happiest and brightest future in his new sphere.

Dr. Cuthbertson has moved from one research position to another, and of course in the former he had been so much concerned with the practical realities of metallurgy and the practical repercussions of his research results in the industrial field. Armed with this knowledge he will now have an opportunity of building up and creating a new department of metallurgy in a relatively new University. To those of us who know Dr. Cuthbertson, one would congratulate the Council of Nottingham upon a happy choice.

Henry S. Wingate has been elected President of the International Nickel Co. of Canada Ltd. He has also been elected to membership on the Executive Committee of the company and to the Presidency of its United States subsidiary, The International Nickel Co. Inc.

Mr. F. M. A. Noblet was, at the same time, elected Treasurer of both companies.

Ralph D. Parker has been elected General Manager of Canadian Operations of International Nickel.

Mr. F. Marshall, general manager of Radiant Metal Finishing Co. Ltd. for the past six years, has been appointed to the Board of Directors.

Mr. W. Speigler, former manager of the Paint Department of Cox Bros. (Derby) Ltd. since 1951, has now joined the board as a director.

Mr. H. Maxwell has joined the staff of Electro-Chemical Engineering Co. Ltd., as Northern representative. His address is 953 East Lancashire Road. Boothstown, Nr. Manchester. Telephone No. Walkden 2876.

Mr. J. E. C. Vecqueray has joined Aerostyle Ltd. as technical representative for the counties of Leicester, Derby, Notts, Lincoln, Northants and Rutland, where he is well known.

Mr. L. G. Palmer has been appointed representative of Sir W. A. Rose and Co. Ltd. for the counties of Kent and Sussex. He has spent many years in the building trade.

British Paints Ltd. have announced the payment of over £54,300 to their employees in profit sharing bonus after a successful trading year.

Mr. J. W. Adamson, chairman and managing director, recently returned from a business trip to Trinidad where he presided at the opening of the new factory of British Paints (Caribbean) Ltd., at Port of Spain.

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In addition, the editorial staff of INDUSTRIAL FINISHING *are always available as an advisory service on questions affecting finishing.*

Aluminium Pastes. Brochures and technical data sheet give information on "Metana" aluminium pastes for all types of finish. Special reference is made to their "Special 75" of high metal content for high specular effects. Johnson and Bloy Ltd., Metana House, Hind Court, Fleet Street, E.C.4. (80)

Paints, Varnishes and Enamels. Descriptive booklet, colour cards and technical summary deal with a wide range of paints, varnishes and enamels for both industrial and decorative purposes. Includes information on ferrous metal spraying primers, spraying wood primers, varnishes, eggshell finishes, thinners and fillers and anti-corrosive paints. Chinol Ltd., Chinol Works, Watling Street, Dunstable, Beds. (81)

Electric Pulley Block. Coloured pamphlet gives details with photographs, diagrams and technical data of the "Marvex" electric pulley block. It has a lifting capacity of up to four tons with lifting speeds varying from 7½ to 30 ft. per minute, according to load. Graham and Gillies Ltd., 37 Golden Square, London, W.1. (82)

Electrical Measuring Equipment. A 28-page illustrated booklet supplies full information on a variety of *p*H meters, *p*H electrode systems, buffer solution tablets, moisture meters and industrial X-ray apparatus. Marconi Instruments Ltd., St. Albans, Herts. (83)

Mechanical Barrelling Finishing. Coloured, illustrated brochures show a range of barrel machines providing an automatic method of deburring, descaling or polishing precision parts to fine limits and high finishes. Because of the regular action of a slowly rotating, rubber cushioned octagonal cylinder, circulating

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processing chips and special compounds in solution, process is claimed to give consistent results for each batch without damage or distortion. Roto-Finish Ltd., 39 Park Street, London, W.1. (84)

Slotted Angle System. Pamphlet gives illustrated information on quick construction method of wide application in storeroom and factory. Associated equipment —panels, panel stiffeners, hinges, castors, tools and angle cutter—is also shown. Dimensions of angle 3 in. by 1½ in. in 14 gauge steel. Fisher and Ludlow Ltd., Material Handling Division, Bordesley Works, Birmingham 12. (85)

Liquid Spelter Pump. Illustrated sheet describes liquid spelter pump for use from one bath to another or emptying bath contents into metal containers. Rated capacity of the pump is 75 tons of spelter per hour. It is designed for use with all liquid and molten metals up to 460° C. Thompson Bros. (Bilston) Ltd., Bradley Engineering Works, Bilston, Staffs. (86)

Gas-Fired Radiant Panel Units. Pamphlets give illustrations and data on gas-fired infra-fed panel units, 3 ft. by 1½ ft., or 27 in. by 13½ in., which can be built in many desired shapes of tunnel for stoving purposes. They can be used vertically or inclined up to 45° in either direction. An even temperature up to a maximum of 650° F. is claimed to be available over the whole of the panel. Relative gas consumption is claimed to be 1 cu. ft. for every sq. ft of paint finish. Also shown are 2 ft., 3 ft. and 4 ft. diameter tunnel units. Parkinson and Cowan Industrial Products, Cottage Lane Works, City Road, London, E.C.1. (87)

Black, Protective Chemical Finish for Ferrous Metals. A full description of this blacking process together with a diagram of plant layout is given in a pamphlet. Black may be resistance or spot welded and soldered. Wear resistance and penetration for short treatment times is claimed to be much greater than that of the coating produced in the nitrate type bath. Jetal Finishes (England) Ltd., 14 Frederick Street, Birmingham 1. (88)

Spray Booths and Exhaust Equipment. Booklet illustrates and describes a large variety of spray booths of all types for every finishing need and includes information on automatic spraying plants, centralised feed systems and accessories. The Aerograph Co. Ltd., Lower Sydenham, London, S.E.26. (89)

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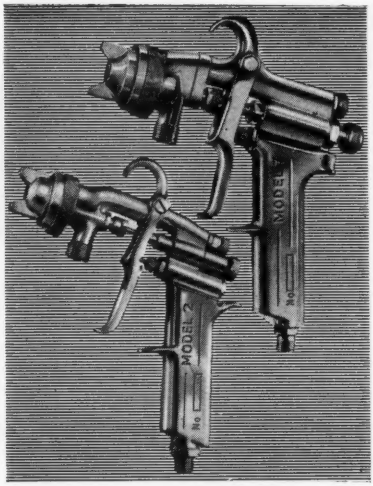

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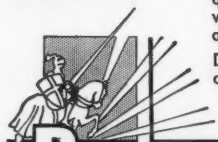

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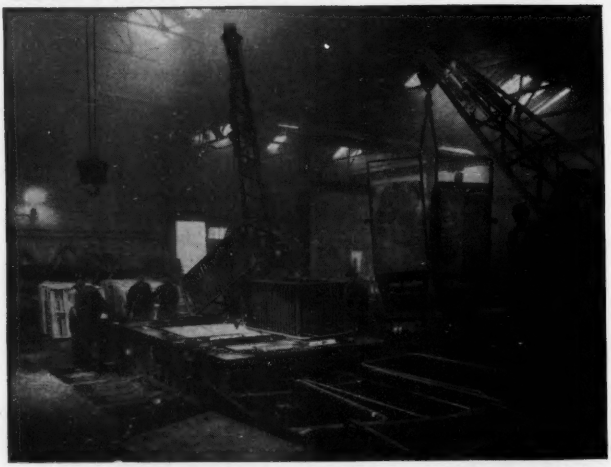

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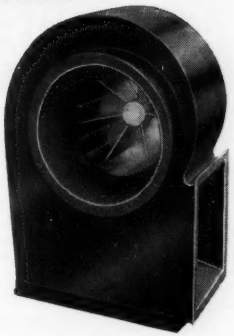

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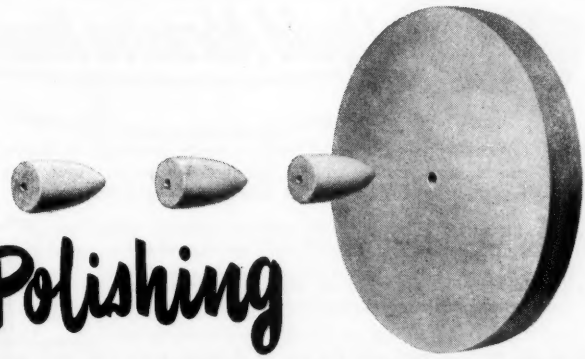

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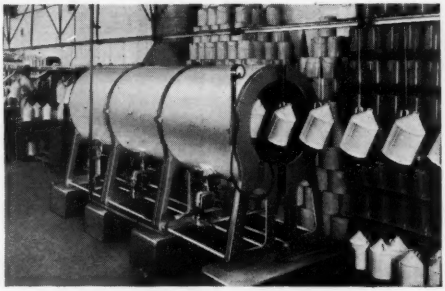

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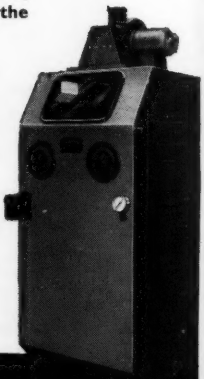

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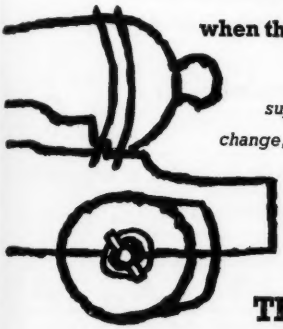

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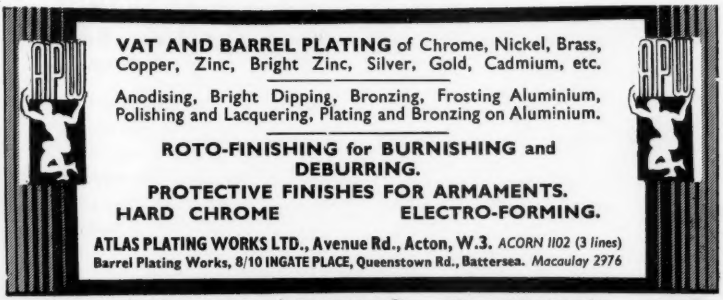
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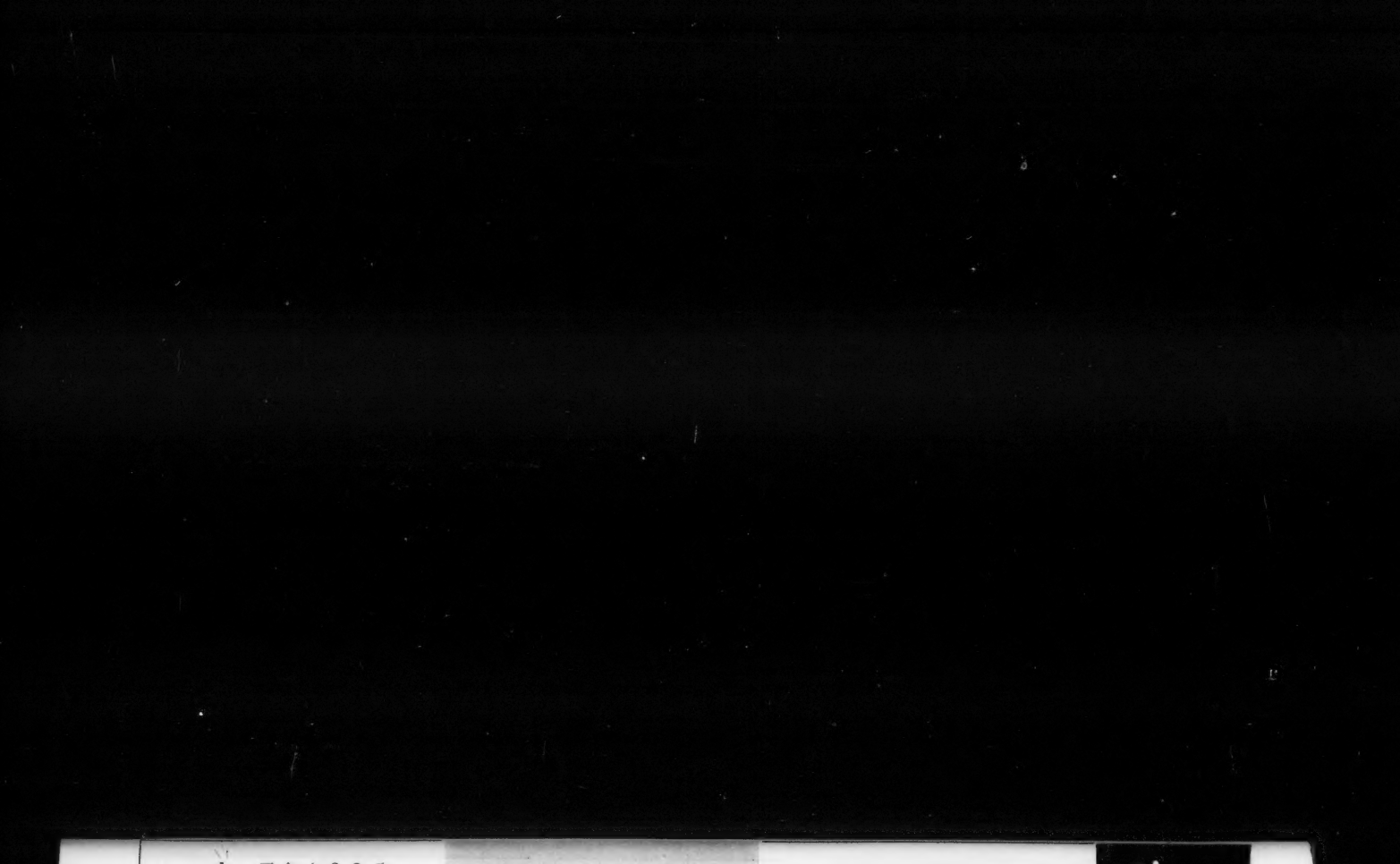
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